Cross-Chain Collaboration in Logistics: Looking Back and Ahead

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CROSS-CHAIN COLLABORATION IN LOGISTICS: LOOKING BACK AND AHEAD

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Title Cross-Chain Collaboration in Logistics: Looking Back and Ahead

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1 INTRODUCTION

Transport is fundamental to our economy and society. This is especially so for the open economy of the Netherlands, which is heavily depending on international trade. The Dutch Statistical Institute CBS (2019) calculates that in 2017 export accounted for 34% (or roughly 250 billion euro's) of the Dutch GDP.

So, logistics is a big deal. And at the same time, it is a challenging industry. Profit margins are usually thin, roads are more and more congested, long-distance intermodal transport is difficult because of the different infrastructures in European countries, and the logistics workforce is steadily decreasing. Therefore, the Dutch government and the logistics industry are keen to keep logistics profitable in the long run, by stimulating relevant applied academic research and innovative business models that reduce inefficiency in transport and logistics and strengthen the position of the Dutch logistics industry in the years to come.

A prominent topic in logistics innovation is horizontal collaboration. To remain competitive in the long run, logistics companies have an incentive to form horizontal collaborations that pool their capacities and as such increase their overall efficiency (Cruijssen et al. 2007, Gansterer and Hartl, 2018). To study and promote horizontal collaboration, the Dutch government has launched a support program in 2010 that is called Cross Chain Control Centres (or: 4C). This program has run for about ten years and will now transition into a new program that is more directly oriented to the societal goal of a sustainable economy, instead of the industry-focused approach of improving logistics functions in the Netherlands. After a decade of investment in research and commercial initiatives in the area of 4C, it is time to look back on the program, both at its achievements and the areas where it did not deliver what was expected.

This report aims to provide an overview of the main results, insights, and other accomplishments in the (academic) field of horizontal collaboration. Furthermore it will give recommendations to governments, commercial companies, and academia on how to proceed with horizontal logistics collaboration in the years to come. This is a short version of a book with the same title that is to appear later in 2020 in the Springer International Series in Operations Research & Management Science. The interested reader is referred to this book for a more elaborate discussion of a decade of cross-chain collaboration in supply chains.

1.1 BACKGROUND

The website of the Dutch Topsector Logistics introduces the concept of Cross Chain Control Centres (4C) as *'the next revolutionary step in supply chain management'*. So clearly, expectation are high. Successful cases have shown that collaboration or joint orchestration can reduce transport cost and distance travelled, lower CO_2 emissions, enable modal shift, reduce capacity shortages, act a catalyst for joint innovation, etc. All this makes that there is a broad desire for more intense logistics collaboration. However, building and maintaining successful 4C has proven to be difficult in practice.

The Dutch 4C program has financially supported over 70 projects, both academic and practice oriented. This synthesis study provides a critical reflection of the results of these projects. This will give input to policy makers deciding on how to proceed with the topic of 4C and horizontal logistics collaboration. Follow-up programs will focus strongly on energy

transition and sustainability and given the promise of 4C that it can reduce emissions by making the transport sector more efficient, 4C will likely remain of interest in the years to come. But first, we will take a 10-year step back in time, to the year 2010, when the 4C program took off.

1.2 SITUATION AROUND 2010

In 2011, Topteam Logistiek wrote a report describing the state of the Dutch logistics industry and defined several concrete ambitions. Several clear challenges, or even threats, were identified. Firstly, in the period 2003-2010 the Port of Rotterdam dropped from rank 3 to rank 11 globally in terms of TEU throughput, being overtaken mostly by fast-growing Chinese ports. Also, on the global Logistics Performance Index (LPI) the Netherlands went down from rank 2 in 2007 to rank 4 in 2009. Then, the strengthening position of China on the world stage was dramatically changing global transport flows in which the Netherlands was a long-time important player. Fourth, there was the centralization wave of European Distribution Centres (DCs), with the risk that the Netherlands would lose some DC activities of multinationals. And finally, the trend towards more customer-specific production and deliveries was transforming the logistics industry.

Next to these threats, there were also several clear opportunities from these dynamics in the logistics industry. First and foremost, the Netherlands is still very well positioned geographically to be the 'gateway to Europe', as the Port of Rotterdam slogan says. In addition to that there is the digitization of logistics processes, which makes it possible to orchestrate logistics flows that take place outside the Dutch borders. The Netherlands was also an early adopter of RFID, Wi-Fi, GPS, and mobile internet in logistics applications, which strongly enables real-time management and orchestration of transport flows. Many of these applications were developed by Dutch software companies, which also provided digital services such as spend and tender management, cargo portals, transport marketplaces, trade compliance accounting, etc.

Taking in these opportunities and threats, Topteam Logistiek (2011) listed five very concrete goals for the year 2020:

1. The Netherlands is the European leader in the global LPI.
2. The Netherlands earns at least € 10 billion from supply chain orchestration services.
3. The number of companies that opens logistics facilities in the Netherlands grows by 30%.
4. The load factor of trucks grows from 45% to 65%.
5. Increase of 50% of higher education logistics graduates

One of the prominent strategies that were developed to reach goal number 4 was to incentivize bundling of logistics flows across supply chains. This idea was still quite new at the time, although the Netherlands was already taking quite a few steps in this direction. For example, Raad voor Verkeer en Waterstaat (2003) mentions the 'Logistics Datahub Netherlands' initiative by the company Informore that aimed at gathering real-time logistics data from many shippers and Logistics Service Providers (LSPs) to find bundling possibilities. And on the academic side, at Tilburg University the first literature review specific for horizontal collaboration in transport and logistics was published (Cruijssen et al., 2007).

Van Laarhoven (2008) found that there were many opportunities for the Netherlands in the area of supply chain orchestration and logistics configuration. The ambition was to lead the Netherlands to the position of market leader for European logistics orchestration functions in 2020. The concept of 4C was the materialization of this ambition and was defined as *the joint logistics orchestration of many big shippers across multiple supply chains*. The idea of a 4C was that by coordinating and orchestrating multiple supply chains together by means of the best technology and experts, efficiency gains and new services would arise. An innovation program by the government was launched to further develop the concept through research and commercial pilots.

Not only in the Netherlands, but across Europe thought leaders and policy makers concluded that increased collaboration in the logistics industry was called for. Before 2010, EU funded research mostly focused on technical innovations in transport infrastructure, vehicles, and ICT systems. This changed with the launch of the FP7 research and innovation program, in which a few clear supply chain calls were included. Later, the supply chain industry finally got a strong foothold in Brussels with the recognition of ALICE (acronym for: *Alliance for Logistics Innovation through Collaboration in Europe*) as a formal European Technology Platform in 2013.

ALICE (2016) has identified five different areas that need to be specifically analyzed and addressed in terms of future research and innovation needs.

These areas are:

1. Sustainable, Safe and Secure Supply Chains
2. Corridors, Hubs and Synchromodality
3. Information Systems for Interconnected Logistics
4. Global Supply Network Coordination and Collaboration
5. Urban Logistics

Since 2016, these five research areas have been taken up by separate working groups. Working group 4 on Global Supply Network Coordination and Collaboration is the group that studies 4Cs and horizontal collaboration in transport and logistics and its main research topics are represented in the ALICE agenda in Figure 1. As can be seen from the figure, horizontal collaboration is the first topic to be taken up on the road towards the final goal of zero emission logistics in 2050. Network coordination and 4C are in fact different ways to refer to a similar ambition, which is to arrive at a far more efficient and clean transport and logistics industry by structural and seamless collaboration between many logistics operators across many supply chains.

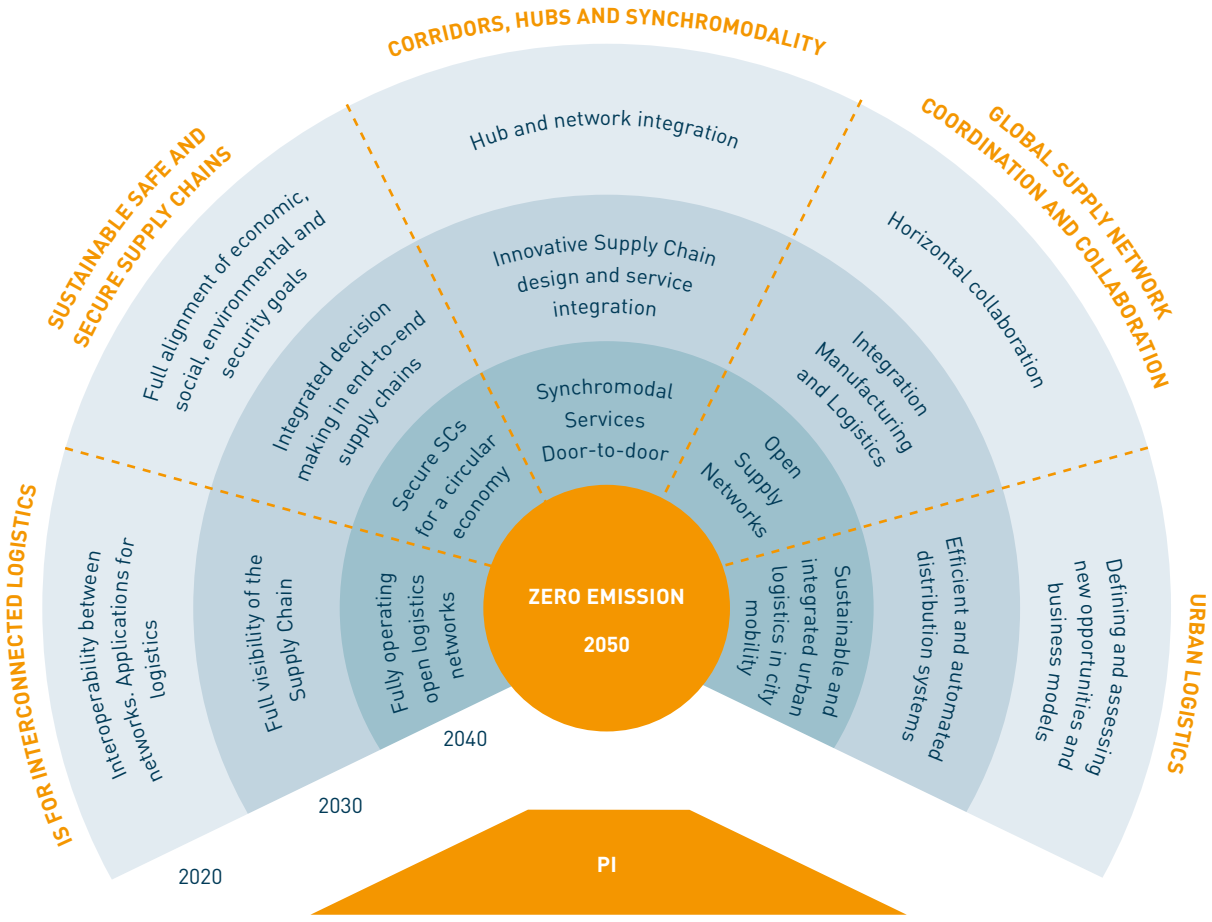

Figure 1. ALICE roadmap

2 BROAD DEVELOPMENTS IMPACTING SUPPLY CHAIN COLLABORATION

Supply chain collaboration is not a topic that is relevant in isolation. It is impacted by some larger global developments that are changing the logistics industry. In this section, we touch upon four major developments that impact supply chains and call for collaborative approaches: 1) Sustainability, 2) Digitization, 3) Increased optimization power and 4) some specific logistics developments.

2.1 SUSTAINABILITY

Following the alarming reports of the Intergovernmental Panel on Climate Change (IPCC), most countries are taking actions to significantly reduce greenhouse gas emissions and to ensure a liveable planet also in the second half of the 21st century and onwards. Several climate conferences have been organized by the United Nations, culminating in the Paris Agreement of 2016.

The transport industry is considered a growing contributor to global climate change. According to the International Transport Forum (ITF) freight transport accounts for about 39% of transport CO_2 emissions and around 8% of CO_2 emissions worldwide. These CO_2 emissions can not only be reduced by technological advances (lower fuel consumption, electrification, etc.), but also significant savings can be achieved through innovative supply chain concepts such as collaboration. Given the eminent threat of global warming, transport inefficiency is a luxury that belongs to the past.

Fortunately, there is a quickly developing body of research that is available to logistics decision makers to reduce the carbon footprint of their logistics operations. A comprehensive review is provided by McKinnon (2018). He shows that there is no shortage of carbon-reducing initiatives. Policymakers and business leaders who are committed to bringing emissions down to levels consistent with the COP21 Paris Climate Change Agreement can use it to come up with regulation, and to design programs and action plans.

2.2 DIGITIZATION

Digitization is a prerequisite for logistics control towers of any considerable size. Fortunately, digitization has been developing at a fast pace over the last couple of years, taking away a huge impediment for the dynamic coordination of multiple supply chains from a single (physical or virtual) location. This digital transformation has received enormous attention in recent years. There are many recommendable books on the topic, but a good overview is given by Raskino and Waller (2015). Especially the fast developments in big data analytics, the internet of things and artificial intelligence are important facilitators for increased supply chain coordination. The uptake of new technology and applications by companies in the logistics industry is however lagging behind, especially by SME's. This leads to a situation that increasing connectivity between companies in a supply network is still a challenge.

2.3 OPTIMIZATION CAPABILITY

The fruits of the increased possibilities offered by the digitization progress in supply chains can only be reaped if the huge data that becomes available can be effectively translated into improved decision making. In other words, do we have the optimization potential in a 4C to work with the immense data coming from multiple individual supply chains with their own definitions, execution, contracts, legal obligations, etc.? This question is of course broad and has many aspects that can be discussed. Here we limit ourselves to stating that advances in computing power and real-time optimization, as well as the more frequent deployment of digital twins and advance optimization software renders the wide adoption of supply chain orchestration more and more realistic. Also plug-and-play solutions, requiring a relatively small investment by companies to take initial steps in optimization, are becoming available which leads to the increased connectivity of smaller companies.

2.4 LOGISTICS DEVELOPMENTS IMPACTING HORIZONTAL COLLABORATION

In this section we mentions some recent developments specifically within the logistics industry that impact the formation and success of horizontal collaborative initiatives. The holistic supply chain point of view we take in this report implies that we also investigate how logistics processes are (or perhaps should) be impacted by urbanization, security concerns, automation, the sharing economy etc. And furthermore, we should analyze how these developments impact logistics collaboration. A valuable resource when discussing recent developments in logistics, is the latest DHL trend radar report (2019). Figure 2 summarizes the main trends observed, categorized by the time they are expected to become relevant to the wide logistics industry and their expected impact.

The topics that are of special importance for supply chain orchestration are: 1) Standardization, 2) Labour market developments, 3) Urbanization and City Logistics, 4) Security, 5) E-commerce, 6) Autonomous vehicles, 7) Physical Internet, 8) Logistics Marketplaces, and 9) The Sharing Economy. For a more detailed discussion of these developments we refer to the book.

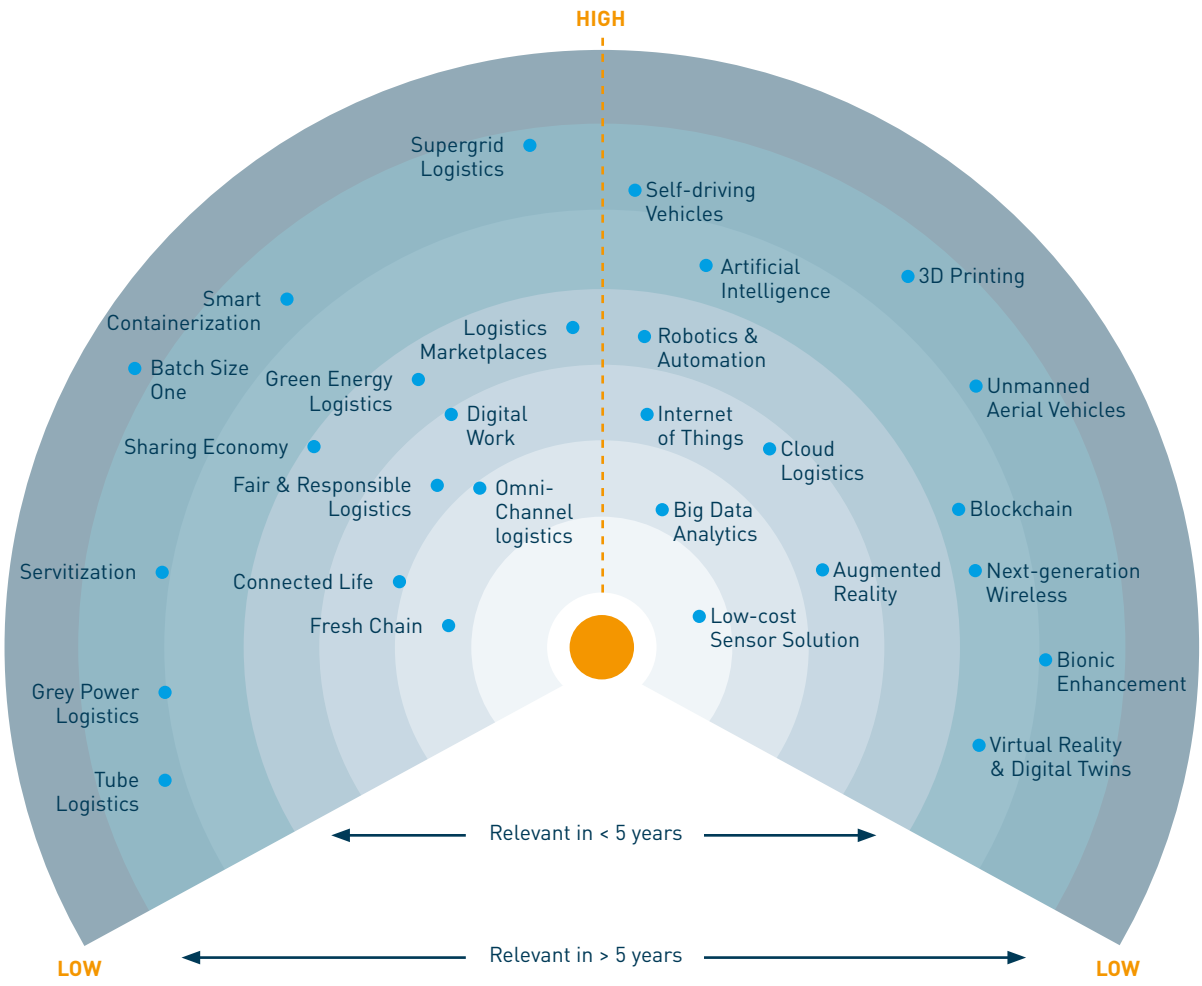

Figure 2. DHL Logistics Trend Radar (2019)

3 LITERATURE REVIEW

Overall, academia has given increasing attention to horizontal collaboration in supply chains. A search on papers on 'horizontal collaboration/collaboration' and 'supply chain' in the period 2000-2019 resulted in the overview of Figure 3. Incidentally or not, the steep rise in published papers per year coincided with the launch of the 4C program in the Netherlands in 2010.

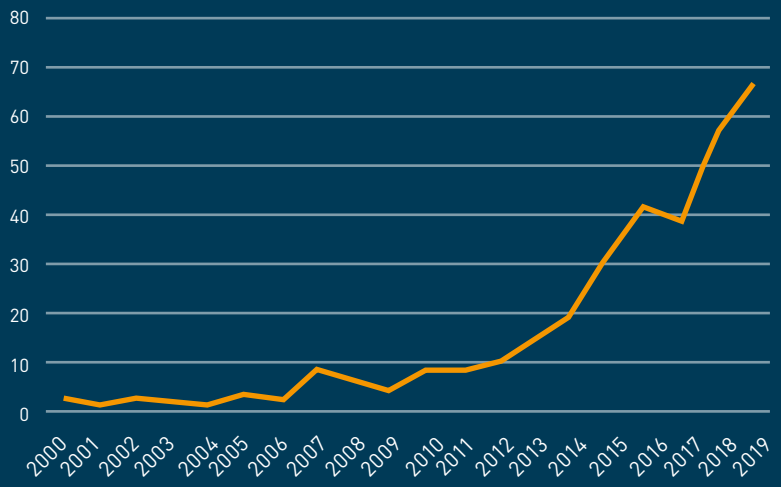

Figure 3. Peer reviewed papers on horizontal collaboration in the period 2000-2019

The growing attention for collaborative logistics in academia is further illustrated by the fact that roughly every five years a new literature review appears, see Table 1.

Horizontal logistics collaborations come in many shapes in practice. To learn from the experiences and to understand which setups succeed and which ones tend not to succeed, a typology for horizontal collaboration is required. A typology is useful for various reasons. First, it can be used as a design tool for new

Year	Reference
2002	Vos, B. et al. (2002), SYnergievoordelen in LOGistieke NETwerken (SYLONET), Resultaten van een literatuurinventarisatie, UvT/TNO Inro, Delft. [In Dutch]
2007	Cruijssen, F., Dullaert, W., Fleuren, H., (2007b). Horizontal collaboration in transport and logistics: A literature review. Transportation Journal 46 (3): 22-39.
2013	Verdonck, L., Caris, A., Ramaekers, K., Janssens, G. (2013). Collaborative logistics from the perspective of road transport companies. Transport Reviews 33 (6): 700-719.
2018	Gansterer, M. and R. F. Hartl (2018) Collaborative vehicle routing: A survey. European Journal of Operational Research 268: 1-12
2019	Pan, S., D. Trentesaux, E. Ballot, G Huang (2019) Horizontal collaborative transport: survey of solutions and practical implementation. International Journal of Production Research, 57: 5340-5361

Table 1. Literature reviews on horizontal collaboration in transport and logistics

initiatives, making sure that all important aspects are carefully considered. Second, it enables finding 'similar' initiatives that can be benchmarked against each other and among which information and experiences can be shared. Third, a typology is a structuring tool that can help to understand which types of collaboration projects have the highest probability of success. Finally, a clearly structured typology can be useful to come up with project setups (combinations of various typology elements) that have not yet been tested in practice.

Considerable academic attention has been given to the various types of horizontal collaboration that are observed in practice and/or conceptually possible in theory. The most commonly referred to typologies for horizontal collaboration initiatives are Lambert et al. (1999), Cruijssen (2006), Leitner et al. (2011), Schmoltzi and Wallenburg (2011), Pomponi et al. (2013), Martin et al. (2018), and Palmer et al. (2019).

Although the discussion of collaboration elements in these seven typologies is rather detailed already, still some relevant characteristics will be unknown once one typology (or in fact all the typologies) is filled out. Although it is certainly valuable to have a typology that is simple and has as few dimensions as possible, it is not helpful if arguably relevant situational elements are not considered. Therefore, we added six additional collaboration characteristics that, based on literature and the conversations with the expert panel, should be added to the typology to make it comprehensive. Together with the dimensions coming from the literature review, these six new elements (marked with an *) make up a new extended collaboration typology that is summarized in Table 2.

Our new typology is richer in dimensions than the typologies found in academic literature today. Most likely, there will still be unknown and unexpected complexities even if a collaboration project is described using this complete typology. However, we are convinced that carefully describing every aspect in this typology improves the chances of success for a collaboration project.

Intensity of the collaboration	**Arm's length**	**Type I**	**Type II**	**Type III**	**Integration**
Decision level	Operational		Tactical		Strategic
Competitive or non-competitive	Competitive			Non-competitive	
Assets shared	Orders	Logistics facilities	Fleet	Market power	Supporting processes	Expertise
Objectives	Cost	Growth		Innovation	Service	CSR
Formalization (contractual scope)	Unwritten agreement	Contractual agreement		Minority stake agreement	Joint venture agreement
Geographical scope	Local	Regional	National	Continental	Intercontinental
Solutions	Co-loading	Consolidation	RCCs	Urban freight	Multimodality
Hurdles	Design	Planning and operations		Business/market	Behaviors
Number of partners*	2	[3,5]	[6,10]	More than 10	
Shippers and/ or carriers led*	Shippers		Carriers		Third party
Government stimulated*	Yes			No	
Partner size*	SME		Large		Mix
Industry specificity*	Industry-specific			Generic	
Collaboration experience*	None		Limited		Broad

Table 2. Extended typology for horizontal collaboration initiatives

4 APPLICATIONS OF CROSS-CHAIN COLLABORATION

In their review paper of cost allocation methods for collaborative transport, Guajardo and Rönnqvist (2016) provide an overview of numerical results found in 55 academic papers. These numerical computations range from small illustrative examples to thorough case studies. For the publications using industrial data, they also listed the potential savings from collaboration, if reported. It shows that collaboration usually brings significant benefits, ranging from 4% to 46% cost savings.

Innovation projects commissioned by the European Commission are another valuable source of practical experience with horizontal collaboration. The projects that are most intricately connected to horizontal collaboration are listed in Table 3.

CO3 (April 2011 – April 2014. 2 million euro.) The EU-funded project 'Collaboration Concepts for Co-modality', or 'CO3' in short, is a project that aimed to develop, professionalize, and disseminate information on the business strategy of logistics collaboration in Europe. The project coordinated studies and expert group exchanges and built on existing methodologies to develop legal and operational frameworks for collaboration through freight flow bundling in Europe.
Nextrust (May 2015 – October 2018. 18 million euro.) The objective of NEXTRUST was to increase efficiency and sustainability in logistics by developing interconnected trusted collaborative networks along the entire supply chain. These trusted networks, built horizontally and vertically, should fully integrate shippers, LSPs and intermodal operators as equal partners. To reach a high level of sustainability, focus is not only on bundling freight volumes, but also on shifting them off the road to intermodal rail and waterway. NEXTRUST focused on research activities that create stickiness for collaboration in the market, validated through pilot cases in live conditions.
SELIS (September 2016 – August 2019. 17.7 million euro.) Project SELIS is aimed at delivering a platform for pan-European logistics applications by creating a unifying operational and strategic business innovation agenda for pan European Green Logistics. The principle of a SELIS Community Node is that it provides a 'lightweight ICT structure' to enable information sharing for collaborative sustainable logistics for all logistics companies, from strategic to operational levels.
AEOLIX (September 2016 – August 2019. 16.2 million euro.) To overcome this fragmentation and lack of connectivity of ICT-based information systems for logistics decision making, AEOLIX established a cloud-based collaborative logistics ecosystem for configuring and managing (logistics-related) information pipelines. The developed ecosystem enables the integration of transport processes through logistics software solutions for cloud-based connectivity and interaction, to support more efficient collaboration in the logistics supply chain than today.
Clusters 2.0 (May 2017 – April 2020. 6 million euro.) Clusters 2.0 is a Horizon 2020 project leveraging the potential of European Logistics Clusters for a sustainable, efficient, and fully integrated transport system. It relies on an open network of logistics clusters operating in the frame of the Ten-T corridors and supporting local, regional, and European development. It enhances coordination among logistics stakeholders within and among European logistics clusters.
LOGISTAR (June 2018 – May 2021. 5 million euro.) This project's objective is to allow effective planning and optimization of transport operations in the supply chain by taking advantage of horizontal collaboration, relying on the increasingly real-time data gathered from the interconnected digital environment. For this, a real-time decision making tool and a real-time visualization tool of freight transport will be developed.

Table 3. European research projects on horizontal collaboration

Despite this list of recent European projects on horizontal collaboration, a strong move of the logistics industry towards collaborative logistics is yet to be seen. Many projects have trouble gathering representative (real-time) company data to test their collaborative solutions. As a result, some projects remain academic or conceptual, whereas the ambition was to bring about many industry test cases. There is a growing conviction also in the ALICE group that the attainable cost reduction through collaboration is apparently less than the perceived cost of the needed transition. This may change once the EU's Green Deal goes ahead, if some other unavoidable external force comes to the stage, or if a specialized trustee or software company finds a silver bullet collaboration model.

It is fair to say that the current application of 4C and horizontal collaboration is slower than maybe expected 10 years ago. The wide uptake turns out to be more challenging for many companies trying. The successful application is subject to a complex set of factors that influence the specific model and the willingness of companies adopting this model. That said, there is a clear movement towards the adoption of horizontal collaboration. The awareness of the opportunities it can bring has risen, many shippers and logistics service providers are open to explore opportunities for them. At the same time a great number of practical industry applications can be identified.

Table 4 shows that already there is an industry specializing in horizontal collaboration support, trustee functions, collaboration software, etc.

Next to these commercial companies that have collaboration as their main business model, also an increasing number of LSPs are investing in proprietary control towers to connect internally and with their suppliers (i.e. carriers). All the major transport integrators (FedEx, UPS, DHL, etc.) have this in place, but also some smaller innovative LSPs are such Ahlers, FM Logistic, Geodis, and LINEAS are moving in this direction.

Some other companies are also making good efforts to enable collaboration. For example CHEP, the pallet pool company, is actively promoting and setting up collaborations between their customers. With their scale and access to transport flow data based on the tracked positions of its pallets, CHEP enables its customers to bundle their flows and reduce empty miles, fuel, CO_2 emissions and costs.

Trustees	Collaboration software	Focused consortium	Control tower
Digitrust	AX4	Fjordfrende	IDS
MixMove	Haulistix	Transmission	Informore
TriVizor	Mix-Move-Match	Netwerk Benelux	Shareship
	Nistevo	Spring Platform	Smartway Logistics
	Quicargo	Greenway Logistics	C6 / King Netherlands
	Stockbooking	Construction Hub Utrecht	
	Stockspots	Greenport Logistics	
	TGmatrix		
	Uturn		
	ChainCargo		
	Cargonexx		

Table 4. Commercial collaboration initiatives

5 CASE STUDY: THE NETHERLANDS

To stay competitive in the globalizing economy, in 2012 the first cabinet of Prime Minister Rutte launched the so-called Topsectors agenda to achieve the following three goals:

1. **Have the Netherlands in the top-5 of knowledge economies in the world by 2020.**
2. **Increase Dutch spending on Research & Development to 2.5% of gross annual product by 2020.**
3. **Establish so-called 'Topconsortia' for Knowledge and Innovation (TKI) by 2015 where public and private partners together invest for more than € 500 million of which more than 40% is financed by companies.**

The logistics industry is one of the topsectors selected. With an added value of around € 53 billion per year and more than 600,000 jobs, it is of great importance to the Netherlands. The Topsector Logistics (TSL) supports companies in many other industries as well, since in the Netherlands logistics is responsible for 8-18% of total costs on average. Therefore, efficient logistics processes are key for many companies' competitive position. An important part of TSL's strategy is the development of the Cross Chain Control Centres. By becoming a global leader in the development and staffing of 4Cs, the Netherlands aims to reach a steady position in the top of global logistics.

Realizing the strong potential of 4C for the Dutch economy and logistics industry, the TSL has made significant investments in applied research into and applications of 4Cs. In the last ten years (2010-2020), a total estimated subsidy of € 5 million was invested. The underlying idea is that horizontal collaboration is essential to achieve the efficiency improvements that are needed to realize the transport sector's contribution in abating climate change. 4C is a viable attempt to attach a business model to the (theoretical) concept of horizontal collaboration.

TSL has funded many innovative projects since 2010. In total, over 70 projects in various industry sectors had a 4C label. With the help of TSL those projects that had 4C as their main theme and thereby particularly helped to further develop the concept of 4C were filtered out. These seven projects will be briefly summarized in Table 5.

4C4More (May 2010 – August 2015. 1 million euro.) The first completed 4C project that was funded by TSL was called 4C4More and was extensively documented in book edited by De Kok et al. (2014). The project was initiated by Unilever and Kuehne Nagel in 2010 and deals with horizontal collaboration in the FMCG industry.
4C4D (December 2010 – December 2015. 706,000 euro) Especially in urban areas, there is a huge potential for bundling of distribution flows that are now fragmented. The 4C4D research project aimed to investigate feasible collaborative supply chain designs, the associated business models and the critical questions of risk and revenue management, specifically in an urban context.
DaVinc3i (January 2011 – December 2015. 1,034,000 euro) The Dutch floriculture sector wants to consolidate their position as the main (virtual) floriculture-trading hub in Europe and has therefore initiated the DaVinc3i project. DaVinc3i developed innovative logistics concepts supported by an information platform and collaborative business models.
4C4Chem (September 2012 – December 2015. 448,000 euro.) Horizontal supply chain collaboration in the commodity industry, such as most chemicals, might even have additional potential compared to other products since commodities are considered interchangeable. In 4C4Chem, relevant decision support models and new operating concepts were developed, evaluated and where applicable tested.
Construction logistics (November 2013 – August 2016. 977,000 euro.) The construction industry in the Netherlands is relatively traditional and in most cases there is no structural logistics orchestration around building sites. Several 4C concepts were developed and tested at the participating companies in actual projects such as residential, utility and infrastructure construction sites.
Next level in logistics collaboration (January 2016 – August 2017. 291,000 euro.) Companies experience various barriers that hinder a wide uptake of logistics collaboration, such as not being able to find suitable partners, struggling to have enough mutual trust and the difficulty of aligning processes and practical difficulties during the implementation phase. The project researched strategies to overcome these above barriers and demonstrate possible steps towards actual logistics collaboration.
COMPOSE (October 2016 – October 2019. 500,000 euro.) This project focused on facilitating collaboration among shippers rather than between LSPs, so on producers and wholesalers that want to have their goods shipped more efficiently. To facilitate horizontal, innovative, and sustainable collaboration at a strategic level, this project combines insights from legal, socio-psychological, supply chain and econometrics literature.

Table 5. Main 4C projects funded by TSL

6 SYNTHESIS

In the previous sections we have reviewed the topic of 4C or horizontal logistics collaboration from a theoretical standpoint slowly towards a practical perspective. The goals of academia and industry are mostly the same: to improve the efficiency of transport and thereby contributing to important economic and sustainability goals. In this section we aim to synthesize this discussion by defining fifteen propositions about 4C. The first eight are based on the initial expectations formulated by Van Laarhoven (2008) at the beginning of the 4C action program. The others are based on the insights of the literature and 4C applications developed in this report.

Table 6 provides an overview of the 15 propositions about 4C and horizontal collaboration. These were proposed to a group of eight Dutch and Flemish experts on the topic of horizontal collaboration, including the author. Using a Delphi approach the experts first individually scored each proposition. These responses were then collected and summarized. This summary was presented to and discussed with the experts in a joint meeting to arrive at a final judgement of every proposition. For a motivation of these judgements, we refer to the book.

	Proposition	True	?	Not true
1	A successful 4C does not only focus on the physical flow of goods, but also redesigns financial control, forecasting, and data management.	■		
2	4C has disrupted the logistics industry using new business models for existing and new companies that are now standard practice.		■	■
3	A 4C can be successful across industry sectors, it does not have to focus on a single industry sector such as fashion, electronics, fresh products, chemicals, etc.	■		
4	A 4C can be initiated from the shipper's side or the LSP side, but to be successful active participation of both sides is required.	■		
5	4C will strongly reduce the kilometres travelled in the Netherlands as well as the total CO_2 emissions from transport.	■		
6	A typical 4C project will become self-supporting (and profitable) within two years after the initial government subsidy		■	
7	Beyond the direct savings in kilometres and CO_2, 4C projects have a positive impact on the innovation level of the Dutch logistics industry.	■		
8	Horizontal collaboration in logistics has been 'over-studied'.			■
9	4C as a term has not caught and should be abandoned.	■	■	
10	4C is a means to an end.	■		
11	The full goals of the 4C program can only be achieved through direct government intervention such as a sufficiently high carbon tax.	■		
12	4C is a logical step in the development towards the Physical Internet.	■		
13	An intra-company control tower is the best way to develop a 4C.			■
14	Governments should take an active role in coordinating specific collaborative logistics systems for example in city logistics.	■		
15	Academic research focuses too much on (methodological) sub-problems, rather than on the bigger picture of how to achieve better transport efficiency.	■	■	

Table 6. Collaboration synthesis propositions

7 CONCLUSIONS AND RECOMMENDATIONS

In this section we will round up our discussion of 4C and horizontal collaboration by formulating some main conclusions and recommendations.

SUSTAINABILITY AS THE UNDERLYING GOAL

4C is a means to an end. The only reason to invest in the 4C concept is that it is believed that it will bring significant changes in main KPIs such as reduction of CO_2 emission and kilometres travelled by road or cost reduction in operations. Therefore, the positioning of a project is clearly important. A project positioned as 'aimed at collaboration' will be more difficult to fund within a company than a project 'aimed at reduction of costs and emissions', while they could be the exact same projects. In Section 2, we have listed a number of recent logistics developments that impact collaboration in the logistics industry. Most often, these developments are aimed at improving efficiency and as a result reducing the negative impact of transport on our climate. In the end, transport is not a goal in itself. It enables consumption, it does not generally improve it: a product is produced at location A and will be consumed at location B, all transport in between should be minimized, as well as the emissions that come with it.

FINDING THE RIGHT INCENTIVES

For collaboration to succeed, it needs to be absolutely clear which problem it can solve (or which value it can create) for the companies involved. Before looking into the opportunities of collaborative logistics, companies should be confident that it will help them to achieve their mission. For the more ambitious forms of 4C, the incentive of cost reductions alone is not enough to move towards collaboration. However, some market circumstances will automatically lead to more structural forms of collaboration. In 2020 we have seen collaboration between shippers being setup due to COVID-19 disruptions in their supply chains. Sustainability imposed by government regulations can also provide an external influencing factor enabling the further uptake of collaboration. In many cases, the sense of urgency must be very strong to move towards collaborative logistics.

PRACTICE VS THEORY: AN INCONVENIENT TRUTH?

Collaborative logistics has become a hot topic in all kinds of media, ranging from rigorous academic journals to mainstream and social media. In addition, numerous case studies and analyses have shown the great potential of 4C and horizontal collaboration to reduce cost and emissions and improve service levels and robustness. Undisputedly, collaboration works in theory, but long-term and scalable success in practice has proven to be difficult to accomplish. As noted by Basso et al. (2019) and others, this can be explained by the practical difficulties in the areas of collaboration design, planning and operations, market circumstances and managerial behaviour. Another possible explanation is that publications on collaboration are often written by 'believers', i.e. people who in principle have a positive attitude towards horizontal collaboration.

CAN WE LEARN TO COLLABORATE?

In the western world, generations of students have learned in their industrial economics classes how competitive behaviour can help companies to reach their goals. Concepts such as predatory pricing to push competitors out of the market, profit maximization by monopolists, first mover advantages, etc. are all examples of rather reckless competition that are extensively studied. Much less attention is given to how companies can work together to pursue common goals. And once working for a company, often personal and company targets re-establish the importance of outperforming your competition. In that sense, horizontal collaboration is a true paradigm shift that deserves strong government support. Although the current generation of secondary school and university students learn much more about the benefits collaboration and despite the support of TSL to make horizontal logistics collaboration work, it to be expected that still it will take some years before collaboration will be commonplace in the logistics industry. Slowly, but surely, it will happen.

DATA-DRIVEN AND DATA-HAMPERED

A lot of formal research has been conducted on the topic of horizontal collaboration. In the first four months of 2020 alone over 30 academic papers about it have been published. It seems however that the actual problem with the acceptance of horizontal

collaboration in logistics lies more in the governance and scalability area than in the calculation of the envisioned savings. The required knowledge and insights are mostly there and most of shippers and LSPs are aware of it. But still companies are waiting for the 'golden' support model for horizontal collaboration to appear. One problem is that usually companies must base their decision to participate in a collaboration on calculations that use static historic data that is gathered for all the potential consortium partners. Currently, these data are not centrally stored and only available in companies' internal systems and in company specific formats. The process of data gathering and harmonization usually takes a few weeks or even months and by that time the situation may have changed, and the calculations made do not fully apply anymore. As Van der Vorst et al. (2016) in their evaluation of the DaVinc3i project on collaboration in the transport of (perishable) flowers put it: "also information has a best-before date". It is worth noting that European initiatives such as Secure SCM and iCargo aim to solve this problem.

RECOMMENDATIONS

The performance of the logistics industry in general and of innovative concepts such as 4C does not only depend on actions taken by LSPs and shippers, but also on government regulations and advancements in scientific knowledge. We will therefore end this report by formulating some recommendations specifically for three stakeholder groups, namely business, governments, and academia (Table 7).

Business
• Expect and accept somewhat longer payback periods for collaboration projects • Allow some additional flexibility in transport contracts and Service Level Agreements • Share best practices and communicate successes • Standardize where possible • Learn to collaborate, invest in required skills
Academics
• Conduct more research on the business models for collaboration • Do not oversimplify: investigate combined horizontal and vertical collaboration • Assess the effects of full standardization on macro level • Solve the profit sharing hurdle • Describe archetypical collaborations • Describe how the logistics industry would look like under full collaboration
Policy makers
• Move from gathered theoretical insights to practical implementations • Where suitable, switch from stimulating to regulating • Invest in logistics clusters and corridors • Focus attention on implementation of collaboration at SMEs

Table 7. Some recommendations per stakeholder group

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