A citation network analysis of sustainability development in liner shipping management: A review of the literature and policy implications

Based on an analysis of 253 related papers drawn from the Web of Science database, this study examines holistic sustainability research in liner shipping management literature using a citation network analysis (CNA) approach followed by a qualitative analysis of findings. We identify four major research domains, namely shipping performance, port selection and management, shipping markets, and environment, as well as related sub-domains of shipping performance. We discuss the current research trends and focal issues in these domains with a focus on their implications for policy development. Our results indicate that while the sustainability discourse in the literature has developed and matured significantly over the last decade, generating valuable insights for practitioners and regulators alike, it still struggles with blurry terminology and a lack of holistic frameworks jointly addressing the different aspects of sustainability: Economic considerations of liner shipping are still the main concern, while environmental and social issues are less regarded in the academic discourse. Furthermore, we identify a dearth of studies rooted in managerial or economic theory. In this regard, our study provides insights on the scope of the holistic sustainability discourse in liner shipping management, its contributions to theory and practice, and its implications for the further development of policies addressing sustainability in liner shipping management. We advocate further construct development for sustainability in liner shipping, as well as empirical tests of the antecedents of sustainability practice adoption in the industry for future research.

Keywords: Liner shipping, sustainability, containers, policy

Introduction

In recent years, there is growing managerial attention on the sustainability aspect of shipping, given the immense cargo volume handled and the remarkable externalities caused by maritime transportation activities. Indeed, future scenarios see a massive increase of negative impacts on the environment caused by the maritime industry (IMO 2015). While firms are looking for ways to reduce costs and improve service quality to

enhance their competitiveness, governments and policy makers have a vested interest in reducing the negative externalities caused by shipping activities; as a result, an extensive academic discussion has been started on how to reduce the environmental damages caused by maritime transportation without compromising its economic viability (e.g. (Psaraftis and Kontovas 2010b; Lister 2015; Lai et al. 2011; Lam and Notteboom 2014)).

Even though the World Shipping Council (WSC), comprised of representatives of the major shipping companies in the world, stresses the importance of environmental efficiency and social viability (World Shipping Council 2017), and some liner shipping firms organize in voluntary groups like the Clean Cargo Working Group (CCWG) or the Trident Alliance to address the negative externalities of shipping (CCWG 2015; Trident Alliance 2016), there is still a void of comprehensive frameworks addressing sustainability in maritime shipping (Sampson and Ellis 2015). Indeed, the International Maritime Organization (IMO) has recently emphasized the importance of developing a holistic framework of corporate social responsibility in maritime shipping (IMO 2012).

Several authors have reviewed the economic performance (Lau et al. 2013; Panayides and Song 2013; Meng et al. 2014; Christiansen et al. 2013) of liner shipping and related port operations (Woo et al. 2012; Athanasios, Vitsounis, and De Langen 2010), as well as to a certain extent, environmental (Lam and Gu 2013) and social (Yang, Wang, and Li 2013) implications of sustainability in liner shipping management. Lau et al. (2017) have provided an exhaustive and detailed review of development in the liner shipping industries over the past five decades. Among others, they found sustainability as an emerging issue in the industry that is inextricably linked with various operational aspects such as vessel speed. However, there seems to be a dearth of research that systematically analyses the specific evolution of sustainability efforts in the liner shipping industry. Furthermore, it appears that most studies on liner shipping sustainability are

confined to one or two dimensions, focusing only on specific aspects of sustainability rather than discussing it from a holistic perspective.

However, it is highly desirable to assess whether the literature is moving towards an inclusive understanding of sustainability and whether the discourse on sustainability is developing and maturing. Doing so can provide insights and tools required for policy makers to regulate the social and environmental impact of the industry without hampering its economic competitiveness. Consequently, this paper employs a citation network analysis (CNA) to survey the literature on sustainability in liner shipping , including both shipping companies and on-shore supply chain partners of liner shipping companies (e.g., ports and container terminals, due to their connecting role in facilitating liner shipping operations and impacts on sustainability performance in liner shipping networks (Lam and Notteboom 2014)). This study is guided by the following research questions:

- What is the current status quo of sustainability research in liner shipping management?
- What are the contributions of the current body of the literature on sustainability in liner shipping management to theory and practice, and what implications do they hold for future regulatory policies to govern liner shipping operations?
- What are the main focal issues and upcoming trends currently discussed in liner shipping management regarding sustainability?

Conceptual Development

Sustainability and related concepts like corporate sustainability, corporate social responsibility, and sustainability development are discussed widely in multiple bodies of literature. Yet, there is no universal definition of sustainability, and the measurement of related constructs is largely dependent on the specific manifestation of the concept and

the field of research it is applied to (van Marrewijk 2003; Montiel and Delgado-Ceballos 2014). While most of these concepts are rooted in the Brundtland report that postulates the long-term orientation of sustainability through *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development 1987), specific manifestations of the sustainability idea show nuanced differences. For example, the sustainability development literature studies the links between environmental problems and socio-economic issues and their role in the development of societies and humanity as a whole (Hopwood, Mellor, and O'Brien 2005). In contrast, corporate sustainability and corporate social responsibility focus on a firm's responsibility to manage its external impacts on environment and society, with a view not to compromise its economic viability (Montiel and Delgado-Ceballos 2014). While corporate sustainability emphasizes an eco-centric perspective (Montiel 2008), corporate social responsibility has a stronger relation to the utility of sustainability for firms by highlighting a positive link to firm performance (Matten and Moon 2008; Waddock and Graves 1997), although this postulated positive link is contested in the literature, and seems to be contingent on several factors (Surroca, Tribó, and Waddock 2010).

Given the different perspectives and definitions of (corporate) sustainability, it is unsurprising that a multitude of theoretical lenses have been applied to explore the impact, motivations, and goals of sustainability in business. Institutional scholars have explored sustainability as externally-imposed demands that affect firms via norms, rules, regulations, and organizational mimicry (Brammer, Jackson, and Matten 2012; Vejvar, Lai, and Lo 2016), and that firms acquiesce to in order to attain legitimacy (DiMaggio and Powell 1983; Scott 2014). In contrast to institutional theory, the stakeholder theory attributes a higher degree of agency to firms: While also adopting an external view of

sustainability by postulating that firms need to engage in sustainability (often in the form of corporate social responsibility) to manage the demands of different stakeholder groups (Jamali 2008), stakeholder theory argues that investments in sustainability enable firms to generate resources like goodwill and stakeholder support (Godfrey, Merrill, and Hansen 2009). Similarly, resource-dependence theory conceptualizes sustainability investment as a way for firms to gain and maintain access to critical resources (Denktas-Sakar and Karatas-Cetin 2012; Vejvar et al. 2017). Theories adopting an internal perspective of sustainability include the resource-based view that considers sustainability as a firm-internal capability to generate sustained competitive advantage (Shi et al. 2012; Yang, Colvin, and Wong 2016). Similarly to the literature on ethical decision-making (O'Fallon and Butterfield 2005; Craft 2013), this highlights the impact of individual characteristics and personalities of executives on sustainability efforts of firms.

While some streams of literature focus on single- or two-dimensional manifestations of sustainability (e.g. environmental management (Bansal and Roth 2000) or corporate social performance (Orlitzky, Schmidt, and Rynes 2003)), all established definitions of sustainability share the notion of three interconnected dimensions, i.e., economic, environmental/ecological, and social, and acknowledge interactions between these three dimensions. Consistently, we define sustainability in liner shipping as a long-term orientation that holistically addresses issues from the economic, environmental, and social dimensions, which we will further elaborate in the specific liner shipping context below. Our adopted definition of sustainability is intentionally broad, as this will allow us to canvas and analyse different approaches and streams of research within the extant liner shipping literature (Montiel and Delgado-Ceballos 2014).

In practice, sustainability in the liner shipping industry is governed by a plethora

of national and regional rules and regulations to address the sustainability aspects of liner shipping. However, international conventions are arguably the most important tool to regulate the liner shipping industry: liner shipping companies are relatively "foot-loose" in their operations and thus able to evade national regulations (Kostova, Roth, and Dacin 2008; Yliskylä-Peuralahti and Gritsenko 2014). Thus, the most important frameworks for regulating sustainability in liner shipping are issued by supra-national bodies like the International Maritime Organization (IMO), which issued the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1974 and has since been updated by six annexes. The IMO has also developed both the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) to regulate training needs, and the International Convention for the Safety of Life at Sea (SOLAS) that focuses on safety management (IMO 1974b, 1974a). The Maritime Labour Convention (MLC), issued by the International Labour Organization (ILO) in 2006, provides a standard for seafarers' working conditions, including working hours, salary, minimum safety requirements, and training (ILO 2006).

Economic Dimension

Transporting goods is the core business of the commercial, profit-oriented maritime transportation industry. Consequently, there is a stream of research discussing economic aspects of liner shipping from strategic (Bang et al. 2012) and operational (Christiansen et al. 2013) perspectives, while other authors explore port operations (Sánchez et al. 2003). Other issues include liner shipping network design (Frémont 2010) and shipping finance (Drobetz, Schilling, and Tegtmeier 2010). In sum, the economic dimension of sustainability in liner shipping receives ongoing research attention (Lau et al. 2013) that contributes to the already well-developed discussion of productivity aspects in liner shipping (Cullinane 2010, 2011).

Environmental Dimension

Environmental issues in liner shipping management include vessel and port emissions (CO_2, NOx, SOx, etc.), dredging, handling of waste and waste water, marine pollution, invasive species, habitat loss, and the disposal of physical shipping assets (Lister 2015; Lirn, Lin, and Shang 2014). The high ecological impact of liner shipping is exacerbated by an increase in the number of liner shipping routes and an over-concentration of traffic flows in maritime port regions (Ducruet 2017), which can lead to significant environmental deterioration among routes and in hub areas. Unsurprisingly, this causes a growing demand for environmentally friendly solutions in maritime transportation, and as a result, the environmental dimension of sustainability in liner shipping receives growing research attention. For example, Lai et al. (2011) focus on the managerial aspect of liner shipping and define green shipping practices that include company policies and procedures, shipping documentation, shipping equipment, shipper cooperation, shipping materials, and shipping design and compliance. From an operational perspective, many methods to reduce the environmental damages caused by shipping have been explored, and some of these methods have been found to lead to cost reductions. For example, slow steaming, i.e., lowering vessel speed to reduce emissions and bunkering costs, has been thoroughly discussed in the literature (Yin et al. 2014; Woo and Moon 2014; Ferrari, Parola, and Tei 2015). However, managing the trade-off between environmental and economic performance in liner shipping is not a straightforward issue and much discussed in the extant literature (Psaraftis and Kontovas 2010a; Mansouri, Lee, and Oluwakyode 2015). Other authors discuss environmental governance in maritime shipping (Lister 2015) or focus on ports by discussing the greening of port operations (Lun 2011; Lam and Notteboom 2014) and hinterland connections (Lam and Gu 2013).

Social Dimension

Social sustainability aspects of liner shipping include safety and security management (Hetherington, Flin, and Mearns 2006; Thai 2009), health issues and seafarers' welfare (i.e., stress and fatigue levels, social isolation, quality of accommodation and working conditions (Doyle et al. 2016; Thomas, Sampson, and Zhao 2003)), maritime education and training standards, impact on society and local communities, and regulatory compliance (Sampson and Ellis 2015). While there is extensive research on safety management and accident prevention (Yip 2008; Trucco et al. 2008), these papers focus predominantly on the economic implications of maritime accidents (i.e., supply chain disruptions, reparation costs, loss of vessels, etc.). Similarly, the question of a vessel's flag is mostly discussed based on economic implications, but bears significant social implications (i.e., manning costs, taxation, regulations in effect, etc. (Kavussanos and Tsekrekos 2011)). However, more and more authors have started to explore social aspects related to liner shipping operations. Fafaliou, Lekakou, and Theotokas (2006) discuss social welfare and job satisfaction in the Greek maritime transportation industry, while Lu, Lin, and Tu (2009) find a positive correlation between financial performance and community involvement in the Taiwanese shipping industry. In terms of port operations, Acciaro (2015) looks at corporate social responsibility implementation and how it can help to improve value creation in seaports. Indeed, seaports are important cargo hubs for entire economic areas and thus inextricably linked with the development of their immediate regions and their corresponding hinterland (Talley 2009); consequently, the extended body of literature offers perspectives on the social impact of liner shipping activities and related economic ripple effects. For example, Ducruet and Itoh (2016) conduct an extensive quantitative analysis to show that port characteristics and specializations have a significant impact on the socio-economic development of their respective hinterland areas.

Holistic sustainability

In order to attain "real" sustainability, the three dimensions of sustainability need to be considered collectively. Policies and management practices affecting one or two dimensions of sustainability will indubitably affect the remaining dimensions; for example, additional security screenings of cargo in ports could lead to an increase in port time, which has been associated with an increase in both costs and emissions (Moon and Woo 2014). Similarly, the observed ongoing increase of container ship size to improve scale economy can improve both environmental and financial performance, but could increase the vulnerabilities of shipping routes (Xu and Xia 2017) to external shocks, and has potential social and economic ripple effects due to the consolidation of cargo flows in fewer main hubs (Ducruet, Itoh, and Joly 2015).

Conversely, ongoing developments in liner shipping sustainability are contingent on exogeneous factors. For example, the recent proliferation of slow steaming practices is not rooted in the industry's efforts to reduce emissions, but the result of bunkering costs, overcapacity in the market, and low freight rates. Should freight rates increase suddenly (e.g. by a sudden surge in demand, or by capacity leaving the market), or should bunkering costs decrease drastically, liner shipping firms would have a strong economic incentive to revert back to full speed (Cariou 2011; Ferrari, Parola, and Tei 2015). Furthermore, due to the international context of the liner shipping industry and its foot-loose nature, policies and regulations aimed at governing its externalities need to be designed in a way that firms are unable to evade them (Yliskylä-Peuralahti and Gritsenko 2014). Indeed, studies show that multi-national enterprises have the option to engage in different levels of sustainability efforts in different institutional contexts (Weber,

Thomas, and Rao 2009), and in some cases even transfer irresponsible and unsustainable practices to foreign subsidiaries (Surroca, Tribó, and Zahra 2013).

Consequently, any research on sustainability in the liner shipping industry should be as holistic and pervasive as possible. While there seems to be a nascent emphasis on a holistic, i.e., tri-dimensional, discussion of sustainability in the shipping literature (Lam 2015; Acciaro 2015), it is not clear whether these efforts are sufficient to supply policy and practice with the insights required to drive the development of sustainability in the industry appropriately. Consequently, this study applies CNA, followed by a qualitative discussion of the extant literature as a more objective approach to analyse major research domains and patterns in the research field of holistic liner shipping sustainability.

Method and Data

One viable research approach to evaluate the evolution of a given research field and to identify gaps of knowledge and potential future research possibilities is through literature review (Tranfield, Denyer, and Smart 2003). Although many authors employ a structured approach to capturing a research field as objectively and exhaustively as possible, their selection of reviewed papers and analytical approach can be subjective, leading to biased discussions (Colicchia and Strozzi 2012). To identify a more objective starting point to review (holistic) sustainability in liner shipping management, this study employs a structured bibliometric approach (i.e., citation network analysis (CNA)). The CNA approach assumes that citation networks depict the systematic proliferation of knowledge over time (Hummon and Doreian 1989). Admittedly, potential bias can still be introduced via keyword selection when performing CNA. However, we argue that using this approach to analyse the structures of these networks allows for a more objective evaluation compared to traditional reviews. The rationale is that only the keyword

selection, but not the article selection itself is biased. CNA is considered a powerful analytical tool to identify established areas and emerging issues (Fahimnia, Sarkis, and Davarzani 2015). Recently, CNA has been increasingly applied to literature in the related fields of operations and supply chain management (Fahimnia, Sarkis, and Davarzani 2015; Fan et al. 2014). For a detailed description of our data collection and analysis methods, please refer to the online resources of this article.

Results

Descriptive Results

A visualization of the publication years of the articles within our sample shows the development of liner shipping literature over the years (see Figure 1). This development can be categorized into three stages that are roughly based on the past three decades. In the pre-2000 era, sustainability in liner shipping operations was barely discussed. In the early 2000s, though, research interest for sustainability in liner shipping management increased: From 2001 to 2010, our sample captured 66 articles on this issue, constituting roughly 26% of all articles captured. After maintaining the same publication trend in the early 2010s, the sustainability discourse massively gained in popularity: 129 articles (so roughly half of the data set) were published in the years 2013, 2014, and 2015 alone. 2016 exhibits a similarly strong trend. For a more in-depth descriptive analysis of our results, please refer to the online resources of this article.

Insert Figure 1 “Publication year of articles (data until February 2016)” approx. here

Citation Network Analysis

We applied the force atlas sorting algorithm in the visualization software Gephi to model our data set as a network graph. Force atlas is a simple approach in which disconnected nodes repulse each other, while connected nodes attract. This results in more influential

and prolific articles moving into the centre, whereas lesser cited articles move to the outer edges of the network. To show the development of the literature over time, we have modelled the network within our sample at three points in time (see Figure 2) in accordance with the three stages of literature development identified in Figure 1. We can see a strong increase of publications and interconnectedness, particularly from 2010 to 2016.

Insert Figure 2 “Development of literature over time” approx. here

At the third, current stage, our sample consists of 253 papers with a local citation score of 221; as a result, we obtain a network of 253 nodes (i.e., papers) and 221 edges (i.e., citations). The network is composed of 84 unconnected nodes, fourteen two-node networks, two three-node networks, and a major network of 135 nodes and 202 edges. For our further clustering efforts, we classified the minor networks (i.e., less than three nodes) and disconnected nodes as “scattered clusters” and removed them from the cluster analysis to focus on the major network only. To identify emerging research domains within this network, we employed the Markov Cluster Algorithm (MCL) to the 135-node network. MCL is an algorithm that clusters networks by simulating a flow within the network, following the rationale that flows are stronger within the centre of a cluster and weaker at the edges. MCL was deemed appropriate as it is fast, powerful, and makes no prior assumptions about the number of clusters within the network (van Dongen, 2000). While not yet widely used in business context, MCL has been successfully applied in other fields of research like bioinformatics (Satuluri, Parthasarathy, and Ucar 2010) and network security (Ahmed and Abulaish 2012). Other potential clustering algorithms also considered by this study include Girvan-Newman, which employs the concept of “edge betweenness” to focus on edges that are most likely connecting distinctive clusters (Girvan and Newman 2002), and approaches that employ modularity, i.e., the number of

edges falling within a group minus the number of expected edges if they were distributed randomly (Newman 2006). Ultimately, MCL was chosen due to its focus on node centrality, which we deemed as a better fit with our subsequent Main Path Analyses (MPA) to identify the most influential studies within the domain. Lastly, MCL was used because of its excellent implementation with our employed bibliometric tools (i.e., Gephi).

The MCL approach resulted in the six clusters solution as shown in Figure 6. We analysed the papers in every cluster thoroughly to find common topics and characteristics and assigned labels to each cluster. We labelled these literature clusters based on their most salient characteristics as “shipping performance”, “port selection and management”, “shipping markets”, “environmental”, “data envelopment analysis” and “shipping network” (see Figure 3).To improve the quality and validity of our findings, we made improvements on the initial cluster algorithm output in the following ways: We manually merged the smaller shipping network with the shipping performance cluster, and the data envelopment analysis cluster, which focuses on port literature, with the port selection and management cluster to generate four distinct research domains. Due to the size of the shipping performance domain (89 papers), we ran a second iteration of our clustering process within the research domain to generate sub-domains; the three resulting sub-domains were labelled “shipping strategy and network”, “scheduling and optimization”, and “multiple objective management” (see Figure 4). These clusters can be seen as the three primary research streams within the current economic discourse: While not distinctive enough to be identified as clusters of their own within the wider sustainability discourse, they form stable clusters (i.e., developed topics) when considered within the boundaries of the economic cluster.

Insert Figure 3 “Citation network and clusters*”* approx. here

Insert Figure 4 “Research domains” approx. here

To proceed with the analysis of the research domains, we used the software Pajek to conduct MPA. MPA identifies the main contributing papers within a domain by modelling the networks within the domains as acyclical (chronological) networks, and simulating flows between the papers that do not cite other sources within the domain (source nodes) and articles that are not cited themselves (sink nodes) (de Nooy, Mrvar, and Batagelj 2011). In line with former research (Fan et al. 2014; Colicchia and Strozzi 2012), we employed the Search Path Count (SPC) method, which focuses on nodes that are more frequently used in paths by calculating traversal weights, which is the ratio of available paths in a node to the total number of paths (de Nooy, Mrvar, and Batagelj 2011). This helped us to identify the most influential articles in each research domain, which we used as a starting point to discuss the domain’s sustainability insights. The result of our MPA per cluster can be found in Appendix B. The following discussion elaborates main issues, as well as practice and policy implications of each research domain by highlighting these central publications from our literature sample in relation to the extant literature.

Discussion of Research Domains

Research Domain 1 – Shipping Performance

Research domain 1a - Shipping Strategy and Network

Central to this sub-domain are strategic considerations by liner shipping companies, particularly when it comes to their network organization. While authors like Lam (2013) and Seo, Dinwoodie, and Roe (2015) discuss how liner shipping operations can be implemented in the broader supply chain context, other authors discuss the fleet mix (Lun and Browne 2009), corporate strategies (Parola, Satta, and Panayides 2015), key

resources (Lu 2007), and service quality (Huang, Bulut, and Duru 2015). A prominent topic in this domain that can clearly be attributed to both economic and environmental issues is container repositioning, which is caused by trade imbalances between areas with different economic developments. Empty containers erode shipping companies' profits, by generating costs without contributing to revenue. Similarly, inefficient repositioning generates excess container movements that result in unnecessary negative externalities (Song and Dong 2015; Song and Zhang 2011). Within our sample, there are several recent publications that address this issue, most notably by Song (e.g. (Song, Dong, and Roe 2010; Song and Xu 2012; Gonzalez-Torre, Sarkis, and Adenso-Diaz 2013)). This trend can be also be observed in the extant literature (Braekers, Janssens, and Caris 2011): Shintani et al. (2007) present an algorithm that simultaneously addresses the issue of deploying ships and containers and show that their heuristic provides a better solution for the issues compared to when they are solved one at a time. Meng and Wang (2011) devise a mixed-integer linear programming model to solve the issue of empty container repositioning in a combined hub-and spoke and multi-port calling system and find evidence for high cost saving potentials. Recent studies assess the potential of empty container exchange between liner carriers to realize cost savings (Zheng, Sun, and Gao 2015), and investigate empty container handling in port hinterland operations in conjunction with the option of repair operations (Hjortnaes et al. 2017).

Research domain 1b - Scheduling and Optimization

Within our sample, scheduling and optimization papers can be regarded as the most representative, as they are at the core of the shipping performance cluster; this might stem from the competitive nature of the liner shipping industry. Christiansen, Fagerholt, and Ronen (2004) is one of the most central publications in both the shipping performance domain and the scheduling and optimization sub-category. The authors of this prolific

publication conduct a systematic literature review of routing and scheduling of liner shipping services. They identify increased collaboration, supply chain integration, computational efforts, and increased focus on optimization and strategic planning as emerging trends and potential future research areas in liner shipping operations. Following up on these recommendations, Agarwal and Ergun (2008) devised a mathematical mixed integer model that heuristically solves the ship scheduling and cargo routing problem, while Alvarez (2009) presents an algorithm that addresses the joint routing and ship deployment problem.

Meng et al. (2014) revisit the liner shipping scheduling and routing literature in a systematic review and acknowledge significant advancements in terms of development. Furthermore, they identify six future research perspectives with practical relevance: intermodal container transportation network design, joint planning between shippers and port operators, reliability and vulnerabilities in shipping networks, green shipping, improvement of benchmarking and modelling efforts, and practical applications. Lau et al. (2017) have shown that these research perspectives are thoroughly discussed in the extant literature, with operational aspects in particular gaining traction over the past five decades. Hoff et al. (2010) discuss fleet optimization and routing aspects with a focus on industrial aspects and connectivity with road freight transportation and call for a better grounding in practical, real-world problems. Wang and Meng (2012) approach the issue of negative effects of uncertain container handling and port congestion times on service reliability stochastically and devise a heuristic that helps to improve scheduling. In another instalment of their prolific review, Christiansen et al. (2013) revisit the ship routing and scheduling literature and conclude that many of the old issues still need to be addressed. They encourage researchers to investigate liner shipping network problems, the development of applicable benchmarks, and how to deal with the increasing

uncertainty in liner shipping.

Research domain 1c - Multiple Objective Management

As observed in both previous sub-domains, there are attempts to address two or three dimensions of sustainability with a single strategy through multi-objective optimization. In this stream of research, economic considerations are distinctly discussed with due consideration of the other two pillars of sustainability (Mansouri, Lee, and Oluwakyode 2015), emphasizing win-win situations. For example, Psaraftis and Kontovas (2010b) discuss technical, market-based and operational strategies to balance environmental and economic performance in maritime transportation. One of the main operational strategies discussed is slow steaming, i.e. the decrease of container vessel speeds in order to lower fuel consumption and emissions, and several authors in this sub-domain discuss the effects of this strategy on both environmental and economic performance (e.g. (Ferrari, Parola, and Tei 2015; Lindstad, Asbjornslett, and Stromman 2016; Yin et al. 2014; Zis et al. 2014)). While there is a general consensus that slow steaming can lower bunkering costs and emissions of container ships at the same time, these findings need to be taken with a grain of salt, as slow steaming lowers service speed and, in turn, schedule reliability and revenue generated (Corbett, Wang, and Winebrake 2009). Cariou (2011) argues that an economic incentive for shipping lines is only given as long as bunkering costs are high (and/or freight rates low), and that powerful market-based mechanisms (e.g. levies) need to be implemented to sustain the benefits of slow steaming in changing market conditions – this highlights the importance of effective policies to regulate the sustainability efforts of the industry. However, regulators need to be careful not to overregulate the industry, as a decrease in cargo velocity might incentivize shippers to move their cargo from container vessels to faster solutions like road freight or rail, which would increase overall

transportation emissions and be detrimental to the competitiveness of liner shipping companies (Psaraftis and Kontovas 2010b, 2013).

In sum, our results show that the shipping performance domain is well-developed. Research papers in this domain focus on operational efficiency and cost reductions, reflecting the highly competitive business environment of the liner shipping industry. However, researchers are branching out to address economic issues with implications for environmental and, to a lesser extent, social aspects, as reflected in research focusing on empty container repositioning, slow steaming, and multi-objective management; this research is of particular interest to lawmakers, as it highlights the intricate interplay between the industry's requirement of economic viability with society's need to govern and limit externalities.

Research Domain 2 – Port Selection and Management

The second largest research domain focuses on port selection and management. This is expected as our study is not confined only to liner shipping companies, but also includes its onshore supply chain partners.

A popular approach to empirically assess the performance of ports and terminals is the Data Envelopment Analysis (DEA) approach. DEA is a non-parametric approach based on linear programming, mostly used in performance evaluation (De Oliveira and Cariou 2011), and has been applied in the maritime sector for over a decade (Cullinane, Song, and Wang 2005; Wang and Cullinane 2006). Particularly the accessibility of historical and economic data from container ports seems to prompt researchers to employ DEA as an analytical approach. Indeed, DEA is used by several authors in our sample (Wu, Yan, and Li 2010; Bichou 2011; Rios and de Sousa 2014) for performance evaluation of ports in different geographical contexts, a trend that we can also witness in

recent literature outside of our data sample (e.g. (Omrani 2016; Yu and Chen 2016)).

The research domain of port management and selection is generally focused on economic issues. Similar to the shipping performance domain, authors focus on operational performance and cost aspects. Yoon, Lee, and Dinwoodie (2015), however, suggest to include environmental performance as a characteristic in future considerations, while Onut, Tuzkaya, and Torun (2011) discuss the option of considering ecological and social impacts of ports. Indeed, the extant literature offers additional insights in particular on the greening of ports. Dimwoodie et al. (2012) offer a framework to include environmental management considerations in port operations, while other authors develop green performance indicators (Lirn, Wu, and Chen 2013) and port sustainability rankings (Asgari et al. 2015).

The literature shows a strong focus on green and environmental policy (e.g. (Chang and Wang 2012; Ng and Song 2010)) and the management of the potential trade-off between operational efficiency and environmental impacts (Chin and Low 2010). However, some authors also pursue a more holistic idea of port management that also includes social factors; for instance, Denktas-Sakar and Karatas-Cetin (2012) employ resource-dependence theory to draft a conceptual framework that considers the organizational relationships between port and supply chain stakeholders, while Acciaro (2015) discusses the concept of corporate social responsibility in the port sector. Research in the focal area of ports as connecting nodes in supply chains (and their corresponding effect on the sustainability of transportation chains) highlights the importance of ports as economic centres with wider implications for entire economic areas and their serviced hinterland (Ducruet, Itoh, and Joly 2015). While policies might target the sustainability performance of ports, as they are not as flexible as liner shipping firms and unable to evade regulations, there might be unexpected cascading societal and economic effects, if

not implemented carefully.

Research Domain 3 – Shipping Markets

Research Domain 3 is loosely connected to the shipping performance domain, and primarily discussing shipping markets. It highlights a growing awareness of the interplay between markets and societies in the liner shipping context. Several papers within our data sample make connections between economic performance and social issues such as quality, safety, and security (Bichou et al. 2007), piracy (Fu, Ng, and Lau 2010) and global social development as a whole (Lau et al. 2013). This matches a trend that can also be observed in the extant literature. While some authors focus on discussing the structural (Luo, Fan, and Wilson 2014; Panayides and Wiedmer 2011) and geographical (Liu, Wilson, and Luo 2016; Lam and Yap 2011) aspects of shipping markets, social issues are prominent in the discussion of seaborne trade: Safety (Hetherington, Flin, and Mearns 2006), security (Chao and Lin 2009; Thai 2009) and quality management (Mitroussi 2004; Shinohara 2005) have strong implications on the success of the entire liner shipping industry, and receive continuous research attention. Other more market-related aspects like maritime piracy have recently moved from being a comparatively niche topic (Birnie 1987) to attain wider recognition in the academic discourse (e.g. (Kondaker, Rahman, and Khan 2013; Hallwood and Miceli 2013; Wong and Yip 2012)), probably due to the increasing number of piracy incidents and their stronger impact on liner shipping (Fu, Ng, and Lau 2010). Other niche issues like maritime education (Lau and Ng 2015; Emad and Roth 2008) and the impact of liner shipping practices on local communities (Sonak, Sonak, and Giriyan 2008) are less prominently discussed. Overall, however, this is the research domain in which the social sustainability dimension receives the most research attention. The interdependencies of liner shipping with global economic development and its impact on society in an increasingly globalised context are certainly worthy of further

investigation, particularly when it comes to the development of future policies. For instance, making sustainability in liner shipping a requirement in maritime education could help to raise awareness of sustainability concerns in the long term and might help to improve the industry's readiness to adopt further practices. Likewise, building on research on the social and economic impacts of liner shipping operations on local communities could help to devise policies that address the sustainable long-term development of specific geographical or economic areas.

Research Domain 4 – Environmental Dimension

While topically close to issues like slow steaming and empty container repositioning, which are predominantly discussed in the shipping performance domain, the papers in this cluster are dedicated to researching the environmental dimension of shipping and related Carbon Dioxide (CO_2) emissions, mostly via policy-based instruments like speed limits or emission taxes. This focus is distinctive enough to emancipate the articles from the bigger shipping performance domain to which it is loosely connected. Most of the papers within this cluster have been recently published. This might indicate an increased effort to discuss environmental sustainability in liner shipping as a major policy-based issue rather than a side topic in economic considerations.

Cariou and Cheaitou (2012) discuss the effectiveness of speed limits and international bunker-levies in maritime transportation for reducing CO_2 emissions. Based on their model, they argue that a speed limit is not only far less effective than an international bunker-levy for reducing emissions, but also comes at a far higher cost. Following this discussion, Lee, Chang, and Lee (2013) model the effect of an international carbon tax on maritime transportation and test it in various scenarios. They argue that as long as the carbon tax is not excessively high, there is little impact on global

economies, and they propose a comparison between an emission trading scheme and a differentiated carbon tax as a potential future research venue. Woo and Moon (2014) use a model to simulate the effect of reduced vessel speed on CO_2 emissions and operational cost and find no evidence for the postulated win-win situation of lower costs and emissions. The same authors also consider the trade-off between environmental and economic goals in port operations by applying simulation modelling, and conclude that the key to reducing both ship-side costs and emissions is an increase in port operations efficiency and the resulting reduction of port time (Moon and Woo 2014).

In connection with our findings in the shipping performance domain, it becomes evident that the liner shipping sustainability literature is characterised by identifying ways to balance environmental impacts and operational efficiency, and there is strong evidence that a postulated win-win of reducing both emissions and costs through increased efficiency cannot always be supported. Apart from the operational practices like slow steaming and empty container repositioning discussed in the prior research domain, and the articles mostly focused on CO_2 emissions and carbon taxes in this domain, the extant literature discusses some additional topics, including sulphur emissions (Yang et al. 2012; Jiang, Kronbak, and Christensen 2014) and port-related emissions (McArthur and Osland 2013; Berechman and Tseng 2012). Lai et al. (2011) conceptualise green shipping practices and discuss their implementation (Lai et al. 2013). From a policy perspective, little research has been done on the issue of invasive species, even though shipping is recognised as one of the major means of introduction of bio-invaders (Molnar et al. 2008): The introduction of invasive species via ballast water and the consequent threat to biodiversity can have severe implications on both the environmental and social development of communities (e.g. by affecting fisheries or aquatic farms), and a thorough economic assessment of this externality would be in order to assess cross-industry

impacts and devise policies to safeguard particularly food-producing industries from unexpected negative externalities.

While anchored in an environmental perspective, the articles in this research domain all show a strong focus on operational efficiency. Even though a strong body of research on environmental issues in shipping is required, and the academic discourse seems to put a stronger focus on the issue, the question remains which dimension of sustainability is preferred in practice when there are no mutual gains to be generated, and environmental and economic objectives are diametrically opposed. While there is a normative desire for "greener" liner shipping transportation, we need to keep in mind that liner shipping is a very competitive industry, and generating profits is the *sine qua non* of liner shipping companies. Thus, changes in market conditions and resource prices might incentivise companies to move away from environmentally friendly transportation. In that case, it seems like effective policies might be needed to support the implementation of environmental and social measures. Consequently, research on efficient policies to regulate environmental impacts of the shipping industry constitute a potential future research area.

Conclusion

Academic Discussion

This study provides the first exhaustive bibliometric literature review of holistic sustainability in liner shipping management. While prior studies have analysed the liner shipping industry in general (Lau et al. 2017), or specific sustainability dimensions of liner shipping (Christiansen et al. 2013; Lam and Gu 2013; Yang, Wang, and Li 2013), we specifically analysed the development of sustainability as a tri-dimensional construct in the liner shipping industry. Our results show that scope of sustainability research in

liner shipping literature has - in line with the increase in research on liner shipping in general (Lau et al. 2017) - gradually increased over the past decades. A sharp increase in publications on sustainability issues can particularly be observed at the beginning of this decade. While most of these publications study only a single dimension of sustainability, there is an increasing emphasis on two-dimensional research on sustainability issues, as evidenced by prolific topics like slow steaming or empty container repositioning. Some authors have also started to embrace a more holistic perspective of sustainability, addressing all the intricate interactions between all three dimensions of sustainability. However, a uniform definition of sustainability is yet to be found; while some authors discuss sustainability, others adapt terminology of corporate social responsibility or environmental management. Further conceptual research is needed to provide a distinct, unified definition of sustainability in liner shipping.

Overall, the scope and scale of sustainability research in the liner shipping literature has made good advancements over the past years. New research domains have emancipated themselves from a predominantly economic discussion to study different aspects of liner shipping, and while operational efficiency and financial performance are focal issues, researcher have started to explore strategies that regard externalities and trade-offs in shipping. The questions remain, however, how much of this discussion is normative and driven by wishful thinking, and how shipping firms manage diverging objectives between sustainability dimensions in practice: Is the industry really steering towards more sustainable operations for the future, or is the industry only interested to embrace sustainability if it supports profit considerations? Will the dynamics of the business environment (e.g., fluctuations in oil prices, socio-economic development, and volatile shipping markets) change the long-term strategies and sustainability agendas of shipping companies, as expected in the cases of slow steaming (Cariou 2011) or cargo

flow concentration (Ducruet and Itoh 2016)? While our findings identify an increase in efforts towards a more sustainable liner shipping industry, recent studies on a broader literature scope suggest that these issues are still comparatively niche to operational and efficiency aspects (Lau et al. 2017). Further empirical studies can help to better understand the managerial logic of liner shipping companies and the externalities of the liner shipping industry in supporting sustainability.

While our main focus in this study was the current status quo of sustainability in liner shipping, and not the theoretical lenses applied to explain sustainability adoption, the lack of any distinct theoretical cluster is a worthy finding of its own. Indeed, looking at all the articles in the data sample, it seems like the current academic discourse on sustainability in liner shipping is surprisingly lacking when it comes to the application of various theoretical perspectives. While some articles employ resource-dependence theory (Denktas-Sakar and Karatas-Cetin 2012) or a resource-based view terminology by discussing resources and capabilities of liner shipping firms (e.g., (Lu 2007)), the other prolific economic theories often associated with sustainability adoption (e.g. stakeholder view or institutional theory) are not represented. Articles in our sample are mostly concerned about the effects of sustainability practices (Lirn, Lin, and Shang 2014; Kontovas 2014), or how to improve specific sustainability performance (Lee, Lam, and Lee 2016; Ugurlu, Erol, and Basar 2016); the questions of how and why liner shipping firms adopt sustainability appear to be considerably less-regarded. Whether this situation is attributable to the comparative infancy of the sustainability discourse in liner shipping research, or the strong competitive pressures in the industry that necessitate research on economic viability is hard to conclude. Further research on the motives and antecedents of sustainability adoption in the industry can advance our understanding of sustainability

in this context considerably and help to devise more effective regulations to facilitate practice adoption. Established economic and business theories can further help to improve our understanding of sustainability (adoption) processes and drivers. For example, adopting an institutional (Scott 2014) or stakeholder (Freeman 1984) perspective to conceptualize sustainability as external demand can help to identify the strongest sustainability pressures encountered by liner shipping firms. Alternatively, by employing upper echelon theory (Hambrick and Mason 1984) or resource based view (Barney 1991), we can explore sustainability as a firm-level construct driven by firm-internal processes.

Topically, we have identified an emerging research domain of environmental-based liner shipping literature that has emancipated itself from core economic discussion. This area of research is of particular interest for regulators and policymakers, as it explores regulation of sustainability issues in liner shipping through external governance bodies. It is worthwhile to follow the development of this new research domain and observe whether it can manage to establish itself as an independent entity. Social issues, however, still seem to be very much embedded in economic considerations. As a result, efforts should be undertaken to shape the field of social liner shipping research in future works, particularly when it comes to the impact of the liner shipping industry on society and local communities in a globalized setting, and to infuse the discussion of economic and environmental issues in liner shipping with social considerations in order to promote a holistic approach to sustainability research.

Within this emerging discussion, however, it is vital to depart from the hopeful, normative discussion of win-win situations and pay attention to situations where a unification of profit-maximizing and sustainable objectives is difficult or thoroughly impossible – how do shipping companies manage this mismatch? And is it possible to

employ policies and regulations to incentivize shipping companies to sacrifice profit for the sake of a stronger investment in sustainability without hurting the industry's competitiveness? Without doubt, it would take considerable time and effort until all aspects of sustainability will be regarded equally within both literature and practice, and given the competitive nature of the business, it is unlikely that this equilibrium will ever be reached – if, indeed, it can be reached at all.

Practical Insights and Policy Discussion

Our findings hold important implications for policy makers: Our results indicate that the current literature is focused on efficiency and win-win situations as a result of cost pressures and strong competition. Indeed, our findings further suggest that multi-objective management is moving increasingly into the focus of practitioners and researchers alike; consequently, policy makers should consider the extended effect of specific policies on all three dimensions of sustainability thoroughly (e.g. slow steaming, container repositioning, etc.). Consequently, any policy (national policy in particular) addressing sustainability in shipping should aim to balance economic viability and external impacts of shipping, possibly by exploring incentives that aim to offset associated costs.

These policies need to be devised with a good understanding of global sustainability development, as liner shipping companies might try to evade or decouple policies that negatively affect their bottom line, as evidenced by other multinational enterprises (Weber, Thomas, and Rao 2009). This might lead to unintended ripple effects in the socio-economic development of entire regions (Ducruet 2017), as liner shipping companies might move from overregulated hubs to areas with less intrusive regulations (Kavussanos and Tsekrekos 2011), and shippers might look towards other, less-regulated

modes of transportation. However, our research shows that the ports as connecting elements in liner shipping could play an important role in enhancing the industry's sustainability performance: Ports are more easily affected by national policy, as unlike liner shipping firms, they do not have the ability to evade national regulation.

Indeed, research on sustainability issues in liner shipping management has increased substantially over the past years, and particularly the notion that some of this research is focusing on the interplay between liner shipping and societal development holds further significant implications for policy makers. On the one hand, any type of policy imposed on the liner shipping industry needs to carefully assess the further impact on other industries; due to prevalent role of liner shipping in international trade, any barriers or obstacles imposed on this connecting industry might have unexpected effects on other industries and entail an aftermath of unintentional economic, environmental and societal effects – for instance, if imposing a CO_2 levy on container vessels increased the cost of transportation, it would also cause more shippers to choose alternative modes of transportation (such as road freight) and could result in an even higher output of emissions at higher economic cost. On the other hand, the increase of academic interest indicates an increasing awareness of sustainability in the liner shipping community that policy makers can capitalize on. Improving public awareness and getting buy-in on the issues of sustainability in liner shipping, for example by paying special attention to the voluntary measures of the shipping industry (e.g. WSC, CCWG), can help to start a dialogue between firms and lawmakers that could potentially facilitate the development of suitable regulations and lessen implementation pains.

In terms of managerial implications, the common body of literature currently offers a detailed discussion on cost reduction, optimization, and efficiency gains in the liner shipping industry. In-depth discussions of scheduling, speed management, liner

shipping network configuration and multiple objective management can be particularly interesting for practitioners who can apply these concepts in practice. However, we see a lack of integrative frameworks that supports practitioners to approach the topic of sustainability holistically, as most research focus on singular or two-dimensional implementation. We hope to provide some guidance for practitioners in understanding the importance of holistic tri-dimensional sustainability by advancing the discussion on topics and providing more insights on different manifestations and definitions of sustainability. The current literature also includes a call by some authors to find a better connection with shipping practice, and to devise more practical applications of sustainability in our research (Meng et al. 2014; Christiansen et al. 2013). We strongly support this argument: not only can the liner shipping practice benefit significantly from increased research efforts on sustainability frameworks and implementation; a closer collaboration with practice and a stronger focus on the applicability of the results might help us better understand the intricacies of the liner shipping market and increase the quality of our research in this important research area in maritime studies.

Limitations

There are several limitations to this literature review that influence the interpretation of our findings. First, some of the decisions on filtering the data set are arguably subjective (e.g., choice of data base, limiting the scope to SSCI-indexed papers, excluding certain non-transportation categories). What is more, repeating the search with a different or expanded selection of keywords will undeniably affect the results. Even though much effort was put into the keyword selection, and they were refined in a process with multiple iterations, we cannot rule out the possibility that not all relevant keywords were captured. We also acknowledge the lack of an exhaustive overview of the entirety of maritime transportation literature (e.g., engineering, geography, marine biology) due to our focus

on providing insights into current trends and research interests solely from a managerial and policy perspective. Furthermore, we are aware that some prominent publications within the field were not captured in our data sample due to aforementioned limitations. This limits our results as certain "missing links" that were not captured by our search string could affect connectivity within and between research domains or give additional insights about geographical proliferation. However, we address this issue by comparing and contrasting our objective results with prominent and proliferate publications in the extant literature. Furthermore, our intention was to capture the trends in the field rather than identifying the most prolific authors and publications, and even if a prominent article was not captured in our dataset, its impact would be mirrored in the articles that are based on it and the transcending discussion in the respective domain. In this regard, the labelling of the research domain can be seen as another limitation: While the methodological approach suggested the structure of the clusters, the labelling of the domains was done by the authors and could thus be to a certain degree subjective. While we are confident that our extended discussion of the research domains provides a good argument for our choice of labels, it is necessary to mention that the labels were decided upon by the authors. Lastly, our results are also affected by the choice of clustering algorithm: While our results show a high degree of robustness, conducting and contrasting different clustering approaches could help to further improve methodological rigour of our work. However, in order not to dilute our focus on sustainability with excessive methodological discussions and due to space limitations, we purposely employed a singular clustering approach (i.e., MCL).

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