Framework for liner shipping connectivity data analytics and research

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Abstract

Purpose – This research proposes a framework to conceptualise the potential realm of data regarding shipping connectivity for application of data analytics which can be used to generate deeper insights with respect to the state of such linkages and potential areas for practical application.

Design/methodology/approach – The study method involved comprehensive presentation of different perspectives of assessing shipping connectivity and levels of data contained within container shipping services and proposed potential application to analyse profitability, performance, competitiveness, risk and environmental impact.

Findings – Advances in capabilities to handle large volumes of data offer scope for an integrated approach which utilises all available data from various stakeholders in analyses of liner shipping connectivity. Research shows how different types of data contained in container shipping services are related and can be organised for application of data analytics.

Research limitations/implications – Research implications are offered to shipping lines, port managers and operators and policymakers.

Practical implications – This research presented a conceptual framework that captures the range of data involved in container shipping services and how data analytics can be practically applied in an integrated manner.

Originality/value – This paper is the first in literature to discuss in detail the different levels of data that reside within shipping services that constitute liner shipping connectivity for application of data analytics.

Keywords Data analytics, Liner shipping connectivity, Container shipping, Shipping service, Port

Paper type Conceptual paper

1. Introduction

Liner shipping connectivity is a key subject of interest in shipping research. The important role played by liner shipping connectivity in facilitating trade for many countries and regions in the world is recognised (Fugazza and Hoffmann, 2017; Lin *et al.*, 2020). Shipping connectivity can be interpreted through shipping services that provide connections between various ports where the impact is manifested by pairings between the ports of origin and destination (Yap and Yang, 2022). Shipping connectivity is viewed as the gateway for access to trade which contributes to economic growth and development. Fugazza and Hoffmann (2017) showed that reduced values of exports are related to the absence of direct shipping connectivity. Liner shipping connectivity is made possible by container shipping services that connect between ports (Yap and Notteboom, 2011). Container shipping services result from interactions between container trade flows and behaviour of shipping lines that lead to vessels being deployed where commercially justified (Song *et al.*, 2016). Following Lam and Yap (2011), a container shipping service is an arrangement to call at a pre-specified set of ports by a single of fleet of vessels. Ships assigned to a container shipping service usually possess the same port of rotation. Contained in container shipping services are the elements of ship capacity and frequency of port call which enable shipping connectivity to materialise (Ducruet, 2020). Information contained in shipping services will also include the number of

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vessels deployed, type of vessel, size of vessel, shipping lines involved and port of rotation (Yap and Ho, 2021). This information allows shipping connectivity to be determined, quantified and analysed using pairings between origin and destination ports or countries (Wang *et al.*, 2017; Saeed and Cullinane, 2021). Shipping connectivity can be differentiated into those operated as mainline or feeder services.

Analysing shipping connectivity is multi-national and multi-dimensional by nature which draws implications for international logistics and trade. A lot of data and information are required in such kinds of analysis. The notion of data analytics applied to shipping connectivity is increasingly popular. Data analytics, broadly defined, is the science of scrutinising data for the purpose of deriving conclusions about the information (Maldonado *et al.*, 2019). Data analytics include diagnostic, descriptive, prescriptive and predictive analytics (Yap *et al.*, 2023). Diagnostic analytics aim to generate insights into findings based on the data and attempt to understand why the results occurred (Dai *et al.*, 2020; Yap *et al.*, 2023). Descriptive analytics aim to discover what has happened by uncovering patterns through analysis of historical data (Wang *et al.*, 2016; Anitha and Patil, 2018). For prescriptive analytics, the aim is to uncover optimal solutions based on stated requirements and objectives using mathematical algorithms and data (Wang *et al.*, 2016; Sheng *et al.*, 2020). Predictive analytics aim to identify patterns in the data with attempts to predict what could happen in the future (Anitha and Patil, 2018; Yap *et al.*, 2023). Applications of data analytics in the maritime industry included the works of Mirović *et al.* (2018), Ubaid *et al.* (2020), Sugrue and Adriaens (2021), and Yap *et al.* (2023). Areas of research involved the aspects of port congestion analysis, freight rate prediction, shipping route analysis, vessel fleet management, vessel traffic management and dealing with the issues of port competition, port competitiveness, market contestability and market development with respect to maritime policies.

Container shipping services present a rich information source for application of data analytics (Yap and Lam, 2020). Research concerning shipping connectivity has seen data analytics employed through different approaches to distil managerial and policy implications. Specifically, data analytics offer the potential to generate research insights by capitalising on large amounts of data contained in such shipping services. There are four areas that have attracted considerable research interest concerning shipping connectivity. The first area concerns port competition and competitiveness. Empirical studies pertaining to these aspects in the context of shipping connectivity saw analyses made from the perspectives of different stakeholders including shipping lines, logistics companies, shippers, terminal operators and port authorities (Yeo *et al.*, 2011; Lam and Dai, 2012; Song *et al.*, 2016; Ha and Yang, 2017; Yap and Zahraei, 2018; Castelein *et al.*, 2019; Kaliszewski *et al.*, 2020). Data related to shipping connectivity included the number of port calls by shipping service and frequency of port calls. Song *et al.* (2016) attempted to differentiate the effects of mainline and feeder shipping services. The studies tend to focus on the port where analyses attempt to associate preferences of port users with different aspects of the port including its infrastructure, maritime access and hinterland connectivity among other indicators. Ducruet *et al.* (2010) proposed that shipping connectivity must be viewed in the context of supply chain networks that extend beyond the maritime leg. Important determinants of port competitiveness and competition in relation to shipping connectivity also included influences exercised by transport infrastructure, location of consumption and production centres, efficiency of port operations, position of ports in trade flows, size of transhipment activities and investments in container terminals by shipping lines (Jiang *et al.*, 2015; Notteboom *et al.*, 2017; Saeed and Cullinane, 2021). The studies suggest the important role of shipping connectivity in affecting preference of users when determining port choice. The studies also allude to the fact that shipping lines are usually able to dictate which ports to call and therefore establish connectivity.

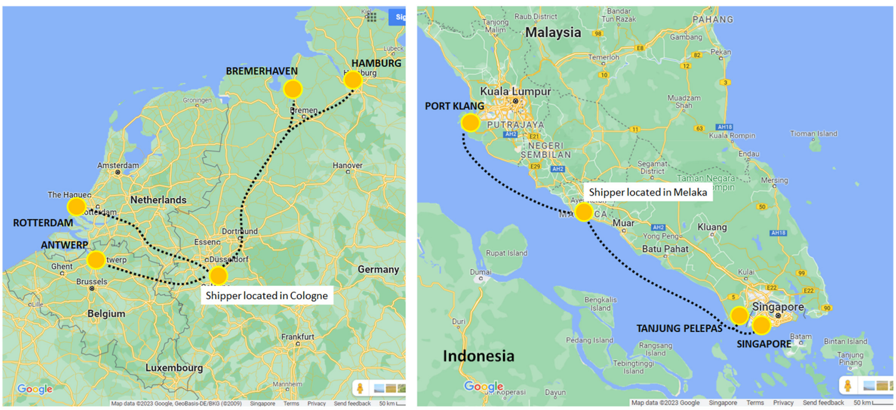
Research concerning attributes of shipping networks is the second area of keen interest. Availability of data regarding operations of shipping services in shipping networks and associated shipping connectivity permitted the use of quantitative approaches including network analysis (Jiang *et al.*, 2015; Da Costa Fontes and Goncalves, 2017; Kim *et al.*, 2018; Xu *et al.*, 2020), graph theory (Bai *et al.*, 2022; Pan *et al.*, 2022) and centrality analysis (Ducruet *et al.*, 2010; Li *et al.*, 2014; Cheung *et al.*, 2020) among other methods. The studies tend to focus on shipping connectivity which is defined through data for container shipping services operated and vessel capacity deployed for selected trading routes. Research by Da Costa Fontes and Goncalves (2017) examined characteristics exhibited by deep-sea and short-sea services, while the study by Kim *et al.* (2018) factored vessel speed. The study by Bai *et al.* (2022) also included use of Automatic Identification System (AIS) data in their analysis of shipping connectivity. The authors further highlighted relevance of liner shipping connectivity being analysed at higher frequencies through monthly data rather than annual data. The studies observed that shipping networks can reinforce the hub position of a port and result in distinct hierarchies. Supply chain structures can be significant in determining the evolution of shipping networks. Shipping networks are not static and can be influenced in part by evolving ship and shipping-related technologies, changing conditions in world trade, as well as responses by terminal operators and local port policies (Ducruet *et al.*, 2010; Xu *et al.*, 2015). Yap and Loh (2019) pointed to the highly capital-intensive nature of container terminal investments which saw the strategy by terminal operators using joint venture agreements to anchor shipping networks by key shipping lines in the port. The studies reiterated the importance of understanding developments in shipping networks when analysing shipping connectivity.

The third area of keen research interest for shipping connectivity concerns trade flows. Studies found a positive relation between shipping connectivity and exports (Fugazza and Hoffmann, 2017; Lin *et al.*, 2020; Del Rosal and Moura, 2022). Methods employed include the use of gravity models (Fugazza and Hoffmann, 2017; Del Rosal and Moura, 2022), linear regression (Lin *et al.*, 2020), maximum likelihood estimation (Hoffmann *et al.*, 2020) and structural equation models (Saeed *et al.*, 2021). Studies that considered the aspect of transhipment activities included the works of Song *et al.* (2016), Yap and Loh (2019) and Del Rosal and Moura (2022). Data relating to shipping connectivity include the number of shipping services, the number of vessels employed, capacity of the largest vessel used and the number of shipping lines. Emphasis of the investigation is on shipping connectivity associated with different pairs of container ports and how the former interacts with various measurements of trade flows. Research also alludes to the important role for economic and trade policies to promote and improve shipping connectivity. The fourth area of research interest concerns port performance. Empirical studies examined attributes of shipping connectivity in relation to port performance and included those by Yeo *et al.* (2011), Ha and Yang (2017) and Kaliszewski *et al.* (2020). Data relating to shipping connectivity considered the aspects of deviation from the main sailing route, frequency of ship call, diversity of trade routes, the number of direct calls by ocean going vessels and vessel size among other indicators. The studies highlight shipping connectivity as an important determinant of port performance.

The literature saw investigation involving selected parameters of connectivity, port infrastructure, port performance and relative positions of ports in global networks or chosen geographical regions to uncover the relationship between traffic flows and inter-port linkages offered by shipping lines. As a whole, these studies reiterated the importance of geographical location and logistics capabilities as key determinants of hub status that offers unparalleled shipping connectivity within the region of competing ports. Also, the literature showed a wide spectrum of methodologies employed in conjunction with data analytics to examine shipping connectivity (Yap and Lam, 2020). However, what is lacking appears to be an integrated method that incorporates the wide range of information available in analyses of shipping connectivity. Hence, there is a need to take full advantage of the wealth of data contained in both demand and supply dimensions of container trade from this perspective. This paper argues that with advances in information capture, storage, processing and analytical capabilities able to handle large volumes of data, there is scope for an integrated approach which utilises all available information from various stakeholders in the industry. Specifically, analysis of shipping connectivity should take into consideration rich data, particularly of those contained in shipping service parameters. As such, the objective of the paper is to propose a framework to conceptualise the potential realm of data regarding shipping connectivity as well as the application of data analytics which can be used to generate deeper insights with respect to the state of such linkages and potential areas for practical application. After the introduction, data contained in a container shipping service will be discussed in detail in Section 2. The framework will be presented in Section 3. Then, implications and future research opportunities are discussed in Section 4, before a conclusion is drawn in Section 5.

2. Data contained in a container shipping service

As of 2021, global container trade is made possible by 5,534 vessels employed in 1,984 container shipping services (MDS Transmodal, 2021). These shipping services offer connectivity to over 2,000 ports in almost 200 countries and territories. As mentioned, shipping connectivity can be determined through shipping services that are connected to a port, country, region or trade route. The set of shipping services that ply between two ports constitutes the first level of connectivity between these two ports. Following this, connectivity between countries and regions can be determined by shipping services that ply between them. Connectivity for trade routes can also be defined by the ports of call involved. Based on the literature, empirical studies on shipping connectivity usually consider shipping services that operate between any two given ports. However, this notion can be deceiving especially when there are alternative routings for an origin or destination which may or may not possess direct access to the sea. In the example of Figure 1(a), a shipper located in Cologne, Germany, has the option of using the services of Antwerp, Rotterdam, Bremerhaven or Hamburg. Similarly, Figure 1(b) shows a shipper located in the port city of



(a) (b)

Source(s): Figure by author; using map data from Google

Figure 1. Location of major container ports in Northwest Europe and Southeast Asia

Melaka, Malaysia, having the option of moving containers through the better-connected ports of Port Klang, Tanjung Pelepas or Singapore. As such, shippers may not be interested only in shipping connectivity pertaining to a particular port *per se* but consider the realm of alternative routings available.

Operational and financial parameters contained within a shipping service offer several sets of information as well as spectrums for data capture, storage, processing and diagnostics. The data can be categorised into different levels from the perspective of a shipping service. With reference to Figure 2, the first level reflects the main attributes of a shipping service. This will include the name of the service, operators involved, the number of Twenty-foot Equivalent Units (TEUs) transported, customers of the service, sailing route and capacity of the vessel employed. Contained within these attributes are data sets that form the second level of information, encompassing the aspects of capacity supply and cargo demand. Beginning with service operators, data contained within this attribute pertain to shipping lines that are involved in the shipping service. This will include the name and profile of the shipping line, fleet management strategy, financial and operational performance of the company and containers transported by the shipping line for the shipping service. From a commercial perspective, this information can be used for key account management. It is also important to recognise there is a third level of data for each of these parameters. For example, contained within the company profile of the shipping line will be data regarding key decision-makers, decision-making characteristics, major shareholders and organisation structure, associated subsidiaries or joint ventures, growth strategy pursued and key contact persons among other aspects. Similarly, there will be a third level of data contained within the aspect of fleet management strategy. The mode of operation may involve different types of capacity arrangements through own fleet of vessels as well as those that are organised using joint services or slot charter agreements.

For data relating to customers of the shipping service, data residing within this attribute will include the name and profile of the shipper, volume of TEU traffic handled for the

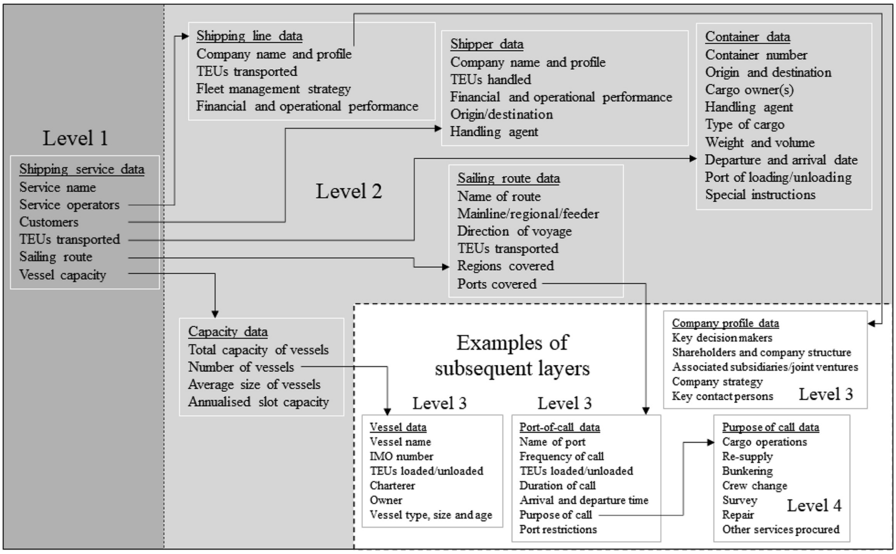


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Figure 2.
Example of different levels of data contained within a shipping service

company, origin and/or destination of the containers, financial and operational performance and handling agent among other aspects. Attributes for shipper data will also include subsequent data levels. A key aspect will be engagement record with the customer including record of previous dealings, experience with quality of services provided, level of satisfaction, promptness of payment and other concerns that may be highlighted by the customer in relation to the shipping service.

The shipping service will be operating on a specific trade route or a combination of trades depending on its configuration. Hence, there will be another set of data contained in the sailing route which can be distinguished by mainline, regional or feeder services. The service can also be distinguished by the direction of sailing which can be eastbound or westbound for main trades as in the case of the Asia–Europe trade. Other important data contained in the sailing route include the total number of containers transported, regions covered and the number of ports covered. Contained within the aspect of port coverage will be the third level of data which includes the selection of ports to call and order of call. Following the choice of ports to cover in the shipping service, there will be data pertaining to the specific port of call. It will include the name of port, frequency of call, container traffic handled at the port, duration of the call, arrival and departure time of the vessel, purpose of the call and any port restrictions that may be in place. Additional levels of data contained within these parameters include the example where the port call can be further distinguished by the terminal facility where the call is made, as well as the purpose of call which may comprise cargo operations, re-supply of provisions, bunkering, crew change and conducting minor repair among other activities.

For containers that are transported in the shipping service, data will include the container number, origin and destination of the container, cargo owner(s), type of cargo carried in the container, weight and volume of the cargo, departure and arrival dates, port of loading and unloading and handling agent tasked to handle the container. It is important to note that there has to be a distinction between origin and destination vs the port of loading and unloading because the final destination of the container may not be the port of call but a location situated further inland which requires mobilising other modes of transportation to carry the container. It may also be the case where a single container can be carrying cargo involving more than one cargo owner. Regarding capacity that is made available for the shipping service, data will include the total capacity of vessels, number of vessels, average size of vessels and annualised slot capacity deployed on the service. The fleet of vessels can be further distinguished by the name of the vessel and International Maritime Organisation (IMO) number, containers transported, charterer of the vessel, the owner and vessel type, size and age. An example of subsequent data level that can be distilled will be the type and size of vessels that are employed. Most container shipping services deploy fully cellular ships. However, there are services that operate semi-cellular ships as well as barges. Using the example of fully cellular ships, these can be differentiated by different sizes ranging from ultra-large container ships, with some reaching above 20,000 TEUs in vessel capacity to post-panamax, panamax and handy size vessels. The capacity of a feeder vessel can range below 500 TEUs for instance. Hence, details of each parameter mentioned will contain subsequent levels of data.

The realm of information presented in Figure 2 potentially involves millions of data points. The spectrum of data also offers many possibilities for application of data analytics in an organised and integrated manner. Many studies in the literature often focus on the first level of data when analysing shipping connectivity. This research highlights other sets of data that are contained within container shipping services that provide such connectivity. The figure further distinguishes the different levels of data involved and how each parameter is related from the perspective of a container shipping service. Following from our discussion, the following section shall present a framework for an integrated approach to data analytics for liner shipping connectivity.

3. Framework for liner shipping connectivity data analytics

The framework is presented in Figure 3. Through various sources of information and types of data, different applications of shipping connectivity data analytics can be made. The areas of application include analysis of profitability, performance, competitiveness, risk and environmental impact among other aspects. Hence, with the ability to harness the wealth of data contained in various parameters of shipping services, there is a potential to develop an integrated approach to performing data analytics on shipping connectivity.

Elaborating on the figure, shipping connectivity can be measured from the perspective of ports, countries, regions and trade routes. Note that connectivity between ports is a subset of connectivity between countries, which in turn is a subset of connectivity between regions. The central indicator used to identify and determine shipping connectivity is through shipping services that provide such links. Examples of locations from the four perspectives are shown in the topmost rectangular row in Figure 3. In the case of ports, they include the ports of Colombo in Sri Lanka, Hamburg in Germany, Mombasa in Kenya and several others. The regions involved comprise South Asia, North Europe, North America, East Africa and other regions. A key actor that provides shipping connectivity between these locations is the shipping service. Using the example of the region of South Asia, there are five countries which are Bangladesh, India, Maldives, Pakistan and Sri Lanka. The number of ports located in these countries totalled 36. In another example of the region of Southeast Asia, there are a total of nine countries, namely Brunei, Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam. In this case, there are 140 ports identified. The list of ports, countries and regions can also be reflected in terms of trade routes such as the Asia–Europe, Asia–Mediterranean, Transpacific, East Asia–Middle East and other trades, in which case, a typical mainline trade route such as the Asia–Europe trade can involve multiple regions, several countries and ports.

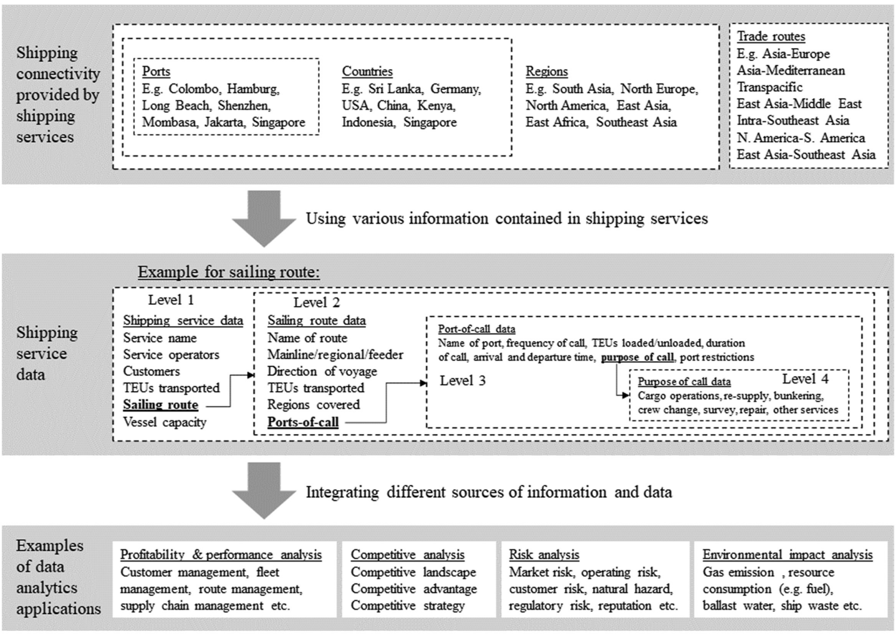

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Figure 3. Framework for liner shipping connectivity data analytics

The framework in Figure 3 further shows different data dimensions that are contained within a shipping service. These data dimensions are those of shipping lines, shippers, cargo transported, vessel capacity provided and sailing route taken. Depending on the scope of study, complexity of data sets involved and the different levels they encompass vary. An example of an investigation for sailing routes that involve different levels of data detail is shown in the figure. Some of the data contained in the respective dimensions are inter-related and can be cross-linked. For example, TEUs handled at the port which resides under data for port of call can be linked to the type of cargo that are carried in containers which resides under data for container. Similarly, data about the charterer of the vessel that resides under vessel data can be linked to data about the shipping line which operates the ship. Therefore, these data points should be integrated with the help of data analytics to conduct various analyses that can facilitate decision-making and policymaking.

With regard to the application of data analytics, we propose firstly that it can be applied in the area of profitability and performance analysis. Key areas for application include those pertaining to customer management, fleet management, route management and, from the broader trade perspective, supply chain management. Profitability analysis can be performed on the different data dimensions as well as different levels of data container within a shipping service as shown in Figure 2. For example, analysis on profitability can be directed at particular customers served, vessel employed, sailing route or port of call made among other aspects. From the perspective of a port, customers will include shipping lines and shippers served. Information for these aspects is reflected at level 2 data in Figure 2. More detailed information pertaining to each customer is shown by level 3 data concerning company profile. Information relating to the port call is shown also by level 3 data concerning port-of-call data. Important data will be containers loaded and/or discharged for each customer and the associated financial and operational performance for the range of services provided. There is potential to dwell deeper into this by examining profitability based on the range of services provided in relation to the purpose of port call (see level 4 data in Figure 2). As such, there will be a set of operating costs and revenues associated with the customer served. The data can also be consolidated for the shipping service as a whole. Similarly, data contained within the various dimensions can be used to analyse shipping operational performance by specific parameters such as schedule reliability through arrival and departure timings, fuel consumption, capacity utilisation and scheduling of vessel maintenance and re-supply of provisions. The analysis can also be consolidated for the shipping service with the objective of maximising profitability and optimising fleet deployment.

Another application of data analytics is in the area of competitive analysis where the data contained within the various dimensions can be used to assess the level of competitiveness and competition faced in shipping landscape. The analysis can be conducted for specific trade routes or viewed from the network as a whole. The major objective is to identify through data analytics any competitive advantages held which can be exploited to advance the entity's interests whether it is commercial or otherwise. For example, for a commercial entity, this can refer to a particular unique selling proposition to tap on for increasing market share, bring in additional revenue or raise profitability with respect to the shipping service or network of shipping services. With reference to the different levels of data contained within a shipping service which is shown in Figure 2, analysis can be conducted with respect to shipping lines, shippers and sailing routes served by the port. Information on these aspects is reflected as level 2 data in the figure. To determine competitiveness, we can begin by drilling down to level 3 and level 4 data to uncover specific reasons for selecting the port in relation to its shipping lines, shippers and sailing routes served. Data analytics has the potential to reveal the actual behaviour of customers of the port through their actions, rather than relying on survey responses. Thus, data analytics has the potential for identifying areas where service differentiation can be made. For a port authority, data analytics can help to identify areas where competitive strategies can be employed to boost the competitiveness and competitive advantage held by the port community as a whole. This is an important consideration in view of the liner and container port industry becoming increasingly commoditised and with a strong focus on competition based on price.

Data analytics could also be deployed to perform risk analysis that incorporates different data dimensions to provide for a more comprehensive approach in a systemic and integrated manner. The analyses conducted can be based on empirical data obtained from the various data dimensions. Examples of risk analyses are those relating to conditions of the market, operations, customer behaviour, natural hazards, partnerships, regulations and reputation among others. The range of applications will also include pre-mortem analysis, sensitivity tests, simulation and horizon scans. An example is to make use of the data to make predictions based on likelihood of occurrences and estimated impact given historical data. These analyses can draw on information found in the different levels of data contained within the shipping service as shown in Figure 2. For example, analysis can be conducted to determine the potential impact on a port because of a major shipping line or alliance relocating its business to a competitor port. Relevant information required will include shipping services that are operated by this shipping line or alliance. As such, the risk analysis will have to draw on different levels of data that are associated with the shipping services identified. Potential issues that can compromise effective response should be determined. There is also potential to allow more accurate identification of key stakeholders based on the nature and effects of the risk including coming up with training plans, communication plans and other measures required. Having a systemic approach to risk analysis can contribute towards better risk management in terms of identifying those risks that should receive priority attention and resources for mitigating actions such as avoiding, transferring, sharing or reducing these risks.

The fourth area where data analytics can see a higher level of deployment is to assess the environmental impact associated with shipping activities and connectivity. Again, this can be ascertained from the perspective of a particular shipping service or an entire network. Elements of environmental impact assessment can be related to emissions of gas and other chemicals resulting from shipping operations, consumption of energy or waste generated including ballast water, cargo spillage, oil discharge and garbage disposal. Regarding environmental impact caused by shipping activities, a key source of information will be level 3 data pertaining to the vessel as reflected in Figure 2. Adverse impact on the environment can also occur in the form of dredging and new port development to accommodate larger-size container ships which can create ecological damage to flora and fauna and not to mention pollution in the form of dust and noise generated from these activities. Environmental sustainability has gained considerable attention especially when associated with the effects of climate change. Although shipping remains among the most environmentally friendly mode of transport, the volume of emission and waste generated remains sizable, with more than 80% of the world trade carried on the backs of maritime transportation.

4. Implications and research opportunities

This section discusses the implications of this study and the associated research opportunities in the field of shipping connectivity. We focus on three aspects, which are shipping lines, port managers and operators, as well as policymakers. Firstly are the implications for shipping lines. The potential for application of data analytics to bring about higher profitability through financially sustainable strategies is immense. With data analytics, shipping lines will be in a better position to optimise deployment of the vessel capacity. Data analytics can also offer higher economic efficiencies as vessel assets are productively employed to achieve higher capacity utilisation and lower unit cost of operation. Gaining greater market by identifying service gaps in the market in the form of unmet customer demand and through the strategy of service differentiation can also help to protect margins against intense price competition especially on the key east–west trades. With the pressure from environmental measures that are implemented such as requirement to use cleaner fuels, data analytics would assist in impact assessment on changing optimum vessel deployment through arrangements in ship schedule, maintenance periods, sharing of vessels, entering into a strategic alliance or chartering slots offered by another shipping line. Data analytics can also be extended to other supply chain assets if the shipping line is also involved in this business. With millions of supply chains involved at the global scale, leveraging the full potential of data analytics to gain advantage over competition will be critical.

Secondly, the implications of data analytics for port managers and operators are the opportunity to achieve better integration of port and terminal assets with those of shipping lines. Data contained within the dimension relating to the port of call can reveal the direction, nature and purpose of a call being made at the port and its facilities. Through data analytics that combines information including those from AIS data for ships, meteorological data and hinterland traffic, port managers and port operators can determine the frequency of such calls which may not accord with published sailing schedules. More importantly, data analytics can be used to determine the revealed preferences of these port users without them stating so. For instance, emergence of new ports may lead to greater competition for hub status where more accurate interpretation of market trends and port user needs will be even more critical. In the case of port managers, data analytics can become a powerful tool especially when negotiating with shipping lines. For port operators, there are the additional dimensions of port safety and security to account for. Data analytics is already incorporated at various degrees in ports around the world in relation to these aspects through port security monitoring systems and vessel traffic systems. Nonetheless, there are more research opportunities for integration with data contained within those of port service providers such as terminal operation systems and e-commerce platforms particularly in areas related to safety and security which can be used for diagnostics as well as predictive tools.

Thirdly for policymakers, data analytics offer the potential for integration of other data that concern broader aspects of the economy and society. Examples of economic concerns will be those the relate to access to international markets, competitiveness of industry clusters, development of transport and port infrastructure, land use planning for port and related-industries, employment creation, environmental sustainability and social equity. For example, in view of a rising shipping volume along a trade route of concern, the decision to relocate a port or terminal to a new location that is deemed better suited to accommodate the latest mainline vessels and incorporate new terminal design and operating systems to achieve higher productivity is a major undertaking from the financial and operational standpoint. Lobbying for support from stakeholders and smooth execution of the project are also critical. Some of these will be directly related to the port sector, while many other issues will be indirectly related to the port. Another example would be monitoring of ship emissions based on AIS data that track ship movements.

5. Conclusion

To summarise the key points and contributions of the study, this paper is the first in literature to discuss in detail the data dimensions and different levels of data that reside within container shipping services that constitute liner shipping connectivity. Analysis of shipping connectivity is multi-dimensional by nature and a rich information source with significant implications for international trade and logistics and where application of data analytics is increasingly popular. The realm of information contained within container shipping services potentially involves millions of data points where operational and financial parameters offer several sets of information as well as spectrums for data capture, storage, processing and diagnostics. The research presented a framework to conceptualise this potential realm of data regarding shipping connectivity for application of data analytics which can be used to generate deeper insights with respect to the state of such linkages and potential areas for practical application in an integrated approach. Specifically, the research considered different perspectives of assessing shipping connectivity and how parameters of container shipping services are related and organised. Potential applications to analyse profitability, performance, competitiveness, risk and environmental impact are proposed. Key areas for application pertaining to profitability and performance analysis include those for fleet management, customer management, route management and even supply chain management from the broader trade perspective. Regarding the area of competitive analysis, data in the various dimensions can be employed to assess the level of competitiveness and competition encountered in the shipping landscape. Data analytics can also be employed to conduct risk analysis by incorporating the different dimensions and levels of data for a more comprehensive approach in an integrated and systemic manner. The paper also discussed assessment of environmental impact associated with shipping connectivity can see a higher level of deployment. Advances in capabilities to handle large volumes of data offer scope for an integrated approach which utilises all available data from various stakeholders in analyses of liner shipping connectivity. The large amount of data sets that are contained within container shipping services and complexity of interactions between the parameters therefore suggest an important role for data analytics. In particular, data analytics can be employed to achieve desired outcomes based on objectives of decision-makers and analysts. The proposed framework and application areas present an original contribution to shipping connectivity research. We recommend that future research can consider parameters factored in the framework and continue to deepen understanding of evolving dynamics of shipping connectivity.

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