The relationship between port choice and terminal involvement of alliance members in container shipping

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Abstract

This paper examines in which ways the changing organizational routines of shipping (i.e., alliance formation and vertical integration in container terminal operations) are affecting the selection of ports of call in intercontinental liner service networks. It first provides a conceptual analysis of the interplay between changes (a) in the organizational routines of shipping lines as part of alliances, (b) the organizational routines at the level of terminal operations (i.e. direct carrier equity involvement in terminal operations) and (c) in port calling patterns. The empirical part examines the relationship between port choice of alliance members and the direct involvement of shipping lines in container terminals in North-West European ports. It does so using binary and non-binary data on the evolution of calling patterns on the North Europe-Far East trade from 2006 to 2017. In addition, the changes in both alliance formation during that period and in the container terminal involvement of carriers in North West European ports are addressed. By examining the relationship between port calling patterns of alliances and the terminal interests of alliance members, the paper addresses an under-researched theme in the extant literature on port choice/selection by carriers. The paper is also of value to port managers and shipping professionals in view of port strategy and planning decisions, as well as shipping strategy formulation.

Keywords: port choice, vertical integration, strategic alliance, container shipping

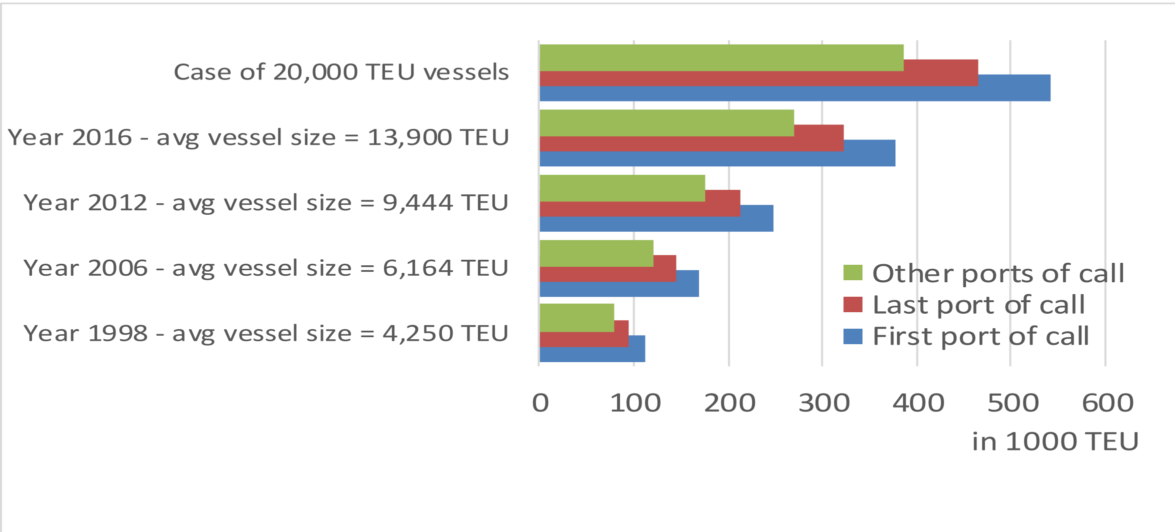
1. Background and rationale of the study

The demand for container handling in seaports has seen strong growth in recent decades. Worldwide container port throughput increased from 88 million TEU in 1990 to approximately 535 million TEU in 2008. After a volume dip in 2009, caused by the economic and financial crisis, growth resumed at a lower growth rate to reach an estimated 691 million TEU in 2016 (Drewry, 2016). The development of containerization went hand in hand with the creation of global container hubs. The 20 largest container ports handled 312 million TEU in 2015 or almost 45% of the world total (data port rankings compiled by Rotterdam Port Authority). The emerging worldwide container shipping networks reshaped global supply chain practices, supporting the globalization in production and consumption. Containerization has been a key driver of modern economic globalization (for a quantitative approach: Bernhofen et al. 2016; for a qualitative one: Levinson, 2016) and the adoption of new supply chain practices (Notteboom and Rodrigue, 2009; Fransoo and Lee, 2013).

The growing demand for maritime container transport has been met via vessel upsizing. While larger vessels allow shipping lines to benefit from economies of scale at sea, terminal operators and port authorities are pushed into making significant investments in equipment and nautical accessibility in view of reducing or eliminating potential diseconomies of scale of such large units in port (Tran and Haasis, 2015). The high requirements in terms of the adaptive capacity of ports and terminals (Notteboom, 2016) has triggered a debate on the (fair) distribution of costs and benefits between shipping lines and port operators when deploying ever-larger vessels (Merk et al., 2015). At the same, the number of weekly liner services on the North Europe-Far East trades, the most important East-West route in volume terms, evolved from 35 in 2006, 26 in 2012, 21 in 2015 to only 17 in the second quarter of 2017. At the same time the average ship size increased from 6,164 TEU in 2006 to over 14,000 in 2017 (data compiled by authors based on online carrier schedules).

The combination of fewer services and larger ships has led to increased competition among container ports to act as a port of call within one or more of these limited number of intercontinental liner services (also called *loops* or *strings*). The stakes are high: a weekly call in one of the services between North-Europe and the Far East now typically generates an annual container volume per port of call of about 300,000 TEU (**Figure 1**). A liner service using only ships of 20,000 TEU, i.e. currently the largest container vessels, could bring this figure to an average of some 450,000 TEU per year per port of call.

Figure 1: Liner services on the North Europe - Far East trade, Average yearly volume per liner service per port of call in North West - Europe (in TEU)



Source: author compilation

Meanwhile, market consolidation and alliance formation in container shipping have resulted in a market characterized by a small number of large shipping groups offering joint services on key trade routes. Not only do ports vie for fewer services serviced by larger vessels, they also have to deal with a few carrier groups with a strong bargaining power to play off one port against the other.

Given that the stakes are high, container ports are actively taking several measures to strengthen their competitive position as ports of call in the global container shipping networks. Such measures include investments in infrastructure (e.g. nautical accessibility, quay walls, etc.); “info-structure” (e.g. Port Community Systems); the implementation of commercial strategies in port pricing and land management; and actions aimed at improving the port-hinterland connectivity. Since the late 1990s, several port authorities have developed strategies allowing shipping lines to develop dedicated or semi-dedicated terminals aiming to secure ship calls and the associated maritime container volumes (Notteboom, 2002; Parola and Musso, 2007).

Container shipping lines have become major players in the container terminal market by entering key ports, using shareholdings, joint ventures with local or global terminal operators, sister companies or subsidiaries focused on terminal operations (Parola et al., 2013; Satta and Persico, 2015). The formation of strategic alliances has resulted in a more complex relationship between the terminal involvement of these alliance members and actual port calls (Parola et al., 2014; Satta et al., 2014).

It is thus worth studying how the changing organizational routines of container shipping (i.e., alliance formation and vertical integration to include direct involvement of shipping lines in container terminals) are affecting the selection of ports of call in intercontinental liner service networks. The role of inter-carrier dynamics, and in particular the involvement of carriers in alliances and in container terminals, is an under-researched theme in the extant literature on port choice/selection by carriers. This paper tests empirically to what extent terminal involvement by one or more alliance members influences the decision of the members belonging to the same alliance to include the port as a port of call in one, or more, liner services of that alliance.

First, a conceptual framework is presented assessing the interplay between changes in the organizational routines of shipping lines as part of alliances, changes in the organizational routines at the level of terminal operations (i.e. direct carrier equity involvement in terminal operations and the dedication of terminal services to carriers) and changes in port calling patterns. The empirical part examines the actual relationship between port choice of alliance members and the direct involvement of shipping lines in container terminals in North-West European ports, using data on the evolution of calling patterns on the Europe-Far East trade from 2006 to 2017 in the light of changes in alliance formation during that period and the changes in the container terminal involvement of carriers in North West European ports.

The results draw attention to the role of inter-carrier dynamics and the terminal interests of carriers in explaining the calling pattern behaviour of these shipping lines. In this sense, the paper also has value to port and shipping professionals in view of port strategy and planning decisions, as well as shipping strategy formulation.

2. A literature review on the role of terminal ownership and alliance formation by carriers in port choice

2.1. Factors effecting port and terminal selection

Port selection/choice is a complex process, which has been studied from various perspectives. Most studies dealing with the choice behaviour of shippers and third-party logistics service providers focus on modal choice and carrier selection, instead of port selection (Lam and Dai, 2012). These market players, however, have an impact on port selection, as changes in supply chains force ports and terminals to seek effective integration into these supply chains (Mangan et al. 2008). Song and Panayides (2008) provide a conceptual contribution to the measurement and quantification of such integration efforts. From previous studies, the main selection criteria of logistics companies and shippers can be identified (see e.g. Nir et al. 2003; Tiwari et al. 2003): a competitive price of port services, reliable services, low time costs for goods, cargo security and damage prevention, facilitation through the use of information platforms and good intermodal connectivity to the hinterland.

The direct impact of shippers and other cargo interests on terminal operations depends on the commodity and type of terminal activity. Typically, in the container business, there are no contractual arrangements between terminal operators and shippers (or their representatives such as freight forwarders). The market demand is exerted indirectly via the shipping lines that have contractual arrangements with the terminal operators.

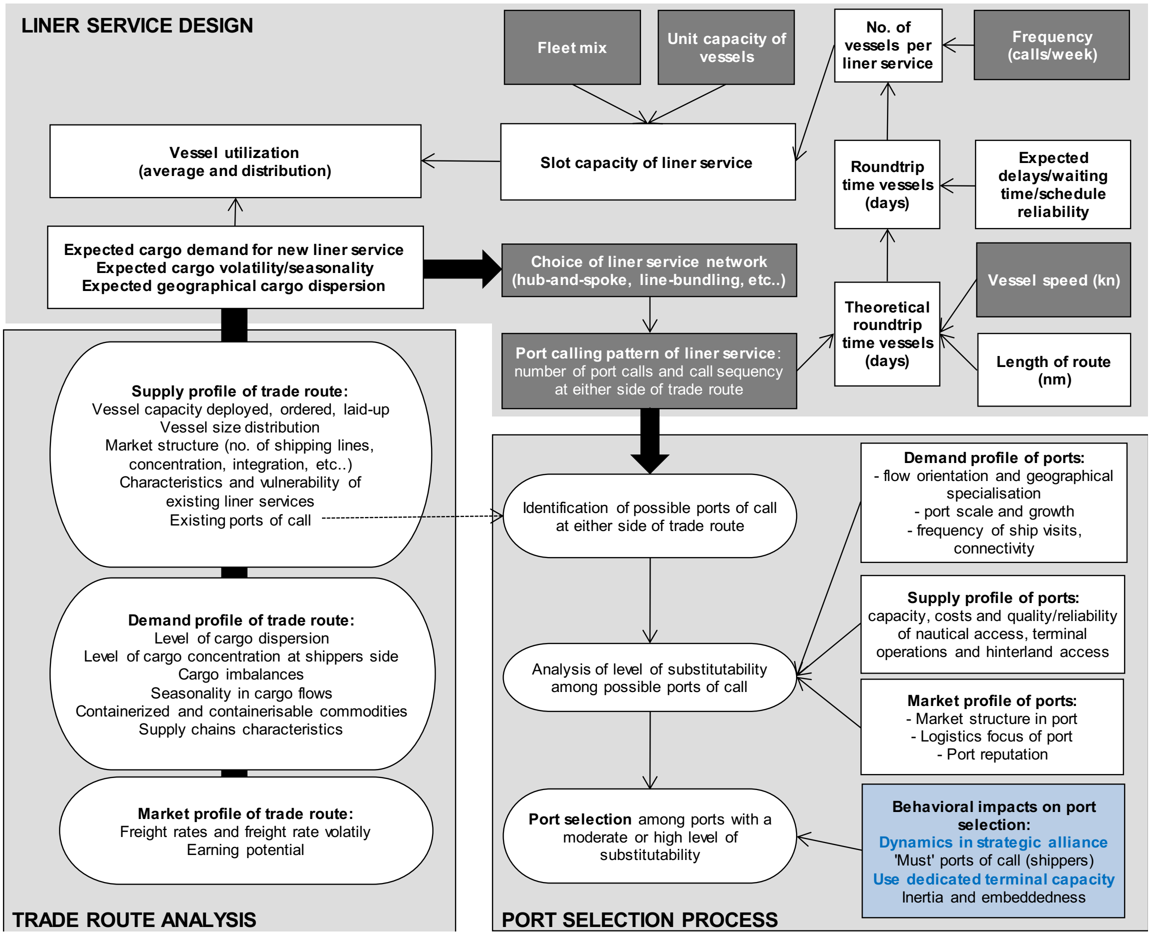
The port choice criteria used by shipping lines are well documented (see literature overviews provided in Lirn et al. 2004; Tongzon and Sawant 2007; Wiegmans et al. 2008; Chang et al. 2008; and Lam and Dai 2012), with four distinctive groups of selection factors relevant to shipping lines distinguished in the extant literature; these factors are related to the demand profile of the port or terminal, the supply profile, the market profile and carrier dynamics linked to carrier operations and cooperation.

Figure 2 conceptualises the port selection process by container lines, combining these four groups of selection factors. The shaded areas refer to decision variables in liner service design. They include the choice on the liner service type (e.g. direct service vs. transhipment), the number and order of port calls, vessel speed, service frequency and vessel size and fleet mix.

From a conceptual point of view, the terminal ownership of shipping lines (or their affiliate companies) and the strategic alliance dynamics among shipping lines belong to the fourth category of port selection factors (see textbox at the bottom left of Figure 2).

However, existing studies offer limited insights into the impact of the involvement of carriers in alliances and in container terminals on port choice/selection by carriers. A decade ago, Wiegmans et al. (2008) demonstrated that strategic considerations at the company level play a role in port and terminal selection. These strategic considerations include alliance developments and the location of container terminals of the carrier or alliance. Other strategic factors include the fit of the port in the trade (or string), the location of key customers, present contracts with independent terminal operators, and the location of decision makers (head office vs. more regional offices). Along the same lines, Slack et al. (2002) noted that port choice was subject to negotiations among the alliance members and can deviate from the choice of one particular member. In the same period, Cariou (2001) argued that a shipping line might be inclined to send more ships to dedicated terminal facilities because of considerations of optimal use. Farrell (2012) discussed examples demonstrating that the investment of a shipping line in a terminal does not necessarily mean that its traffic will stay there.

Figure 2. A conceptual overview of the port selection process and liner service design by shipping lines



Source: adapted from Notteboom (2009) and Ducruet and Notteboom (2015)

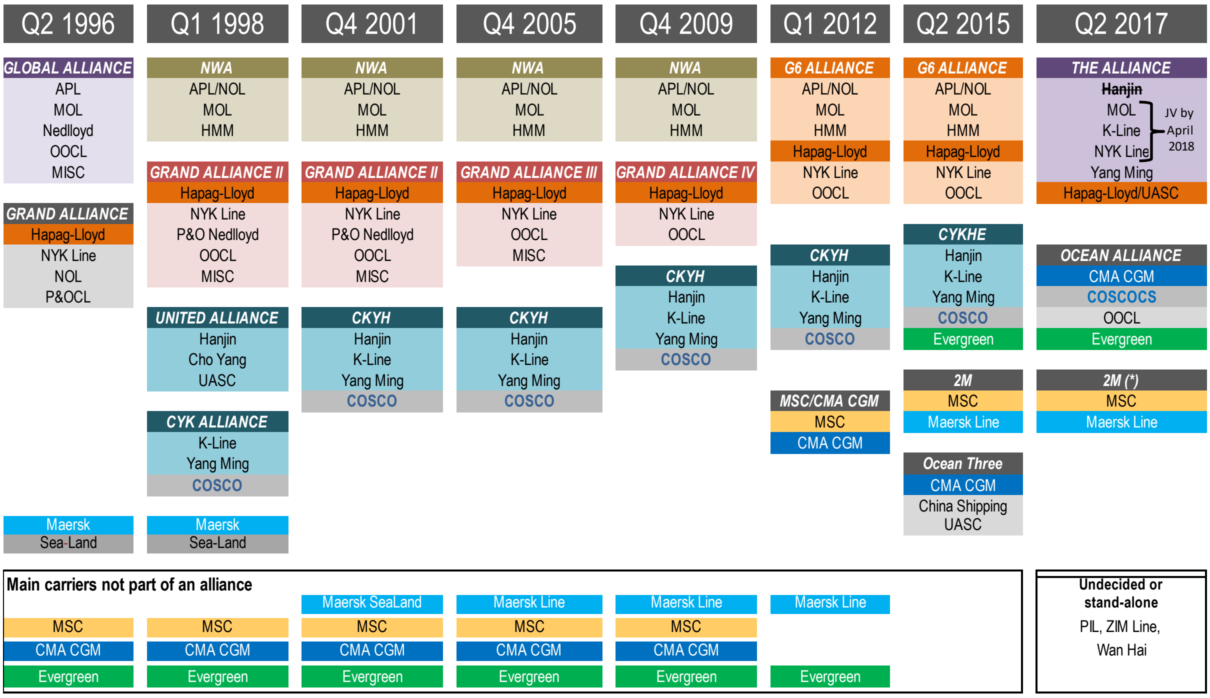
While the above scholars argue that port choices are usually more widely evaluated in the alliances and considerations on terminal ownership of alliance members play a role here, no further detailed empirical evidence was provided on the exact weight or reach of these considerations in port and terminal selection. Furthermore, despite the structural changes that liner shipping is undergoing, there is no recent empirical evidence on port selection practices.

Before developing empirical proof on the impact of terminal involvement in an alliance setting on port choice, a short overview on the aspects which we intend to relate to port choice is provided: i.e. alliance formation and the entry of shipping lines and carrier combinations in terminal operations.

2.2. Formation of strategic alliances in container shipping

Operational co-operation between container shipping companies comes in many forms ranging from slot-chartering and vessel-sharing agreements to multi-trade strategic alliances. The first strategic alliances between shipping lines date back to the mid-1990s, a period that coincided with the introduction of the first post-Panamax containers vessels on the Europe-Far East trade (**Figure 3**). In 1997, about 70% of the services on the main East-West trades were supplied by the four main strategic alliances. At the time of writing in 2017, three alliances were operational in the market: 2M, Ocean Alliance and THE Alliance. The landscape looked very different compared to 2015 when four alliances were still active: 2M, Ocean Three, CKYHE and G6.

Figure 3. The changing alliance structures in container liner shipping



Note: (*) Hamburg Sued has slot chartering agreements with Maersk Line as an interim step to the planned take-over of Hamburg Sued by Maersk Line. Also HMM co-operates with 2M.

Source: adapted and updated from Notteboom (2012)

Research on the rationale for shipping lines to engage in alliances (cf. Ryoo and Thanopoulou, 1999; Midoro and Pitto, 2000; Slack et al. 2002; Song and Panayides, 2002) concludes that the main incentives relate to achieving critical mass in the scale of operation, exploring new markets, enhancing global reach, improving fleet deployment, and spreading risks associated with investments in large container vessels.

Initially, many of the largest carriers did not opt for alliance membership as these firms reached a sufficient scale allowing them to benefit from the same economies of scale and scope that strategic alliances offer. The top six carriers Maersk Line, MSC, CMA CGM and Evergreen are notable examples, while the remaining two top six carriers (i.e. COSCO and Hapag-Lloyd) have always opted for alliance membership despite the scale of their activities. A number of shipping lines such as Evergreen initially did not participate in alliances, for reasons of commercial independence and flexibility. In more recent years, however, even the largest shipping companies have resorted to joining alliances for their survival and to increase margins. The case of Evergreen demonstrates that even outsiders have had to pursue alliance membership.

Figure 3 unveils the dynamic nature of strategic alliances. Yang et al. (2011) examined the stability of liner shipping alliances by applying core theory, concluding that the alliance's stability is significantly related to the structure of members' demands and joint-ships capacity when deciding to opt for a joint-service strategy. Individual shipping lines continue to show a high level of pragmatism when setting up partnerships with other carriers on specific trade routes. Alliance partnerships also changed over time due to mergers and acquisitions, as well as the market entry and exit of liner shipping companies. Examples include the merger between P&O Container Lines and Nedlloyd in 1999, the take-overs of P&O Nedlloyd in 2006 and SeaLand in 1999 by Maersk Line. The more recent wave in carrier consolidation includes the merger between Cosco and China Shipping, the take-over of APL by CMA CGM, the merger between Hapag Lloyd and UASC, the take-over of Hamburg Sued by Maersk Line and the creation of a Japanese super carrier combination of K-Line, MOL and NYK Line to start operations in 2018. Das (2012) identified the nature of resources of the carriers involved and the intensity of competition faced by the carriers as key factors affecting choice between mergers and acquisitions (M&A) and alliance formation. Liner shipping firms tend to prefer M&A when dealing with carriers from their home region, while prior partnership experience of a carrier decreases the chance of the carrier choosing M&A over alliance formation. Alliances can also be affected by the exit of carriers. For example, Malaysian carrier MISC left the Grand Alliance in the late 2000s and Hanjin became the first large carrier to go bankrupt due to continued weak market conditions. Alliances and carrier consolidation are having their full impact on inter-port competition given the large container volumes involved and the shift in the associated bargaining power.

2.3. Entry of shipping lines in terminal operations

Since the late-1960s, a number of major shipping companies such as Mitsui OSK Line (MOL), Evergreen, K-Line and Maersk have experienced a process of vertical integration and diversification into inland transport, terminal operations, warehousing and distribution activities (Parola et al., 2015). These carriers started to vertically integrate, acquiring equity stakes in terminal operating companies or directly managing terminal facilities in order to exploit dedicated services (Slack, 1993; Haralambides et al., 2002; Soppé et al., 2009). Single-user terminals ('dedicated') operated by global container carriers that only handle their own containers started to be developed in some geographic areas like the USWC, Japan and Taiwan (Parola and Musso, 2007). Nonetheless, in recent times, the semi-dedicated formula (i.e., selling spare capacity to third-party customers, which are often partners in shipping consortia or alliances) became much more common, because of the possibility of achieving a higher degree of utilization of the facility, thus reducing management costs.

Scholars underline numerous potential benefits of vertical integration in container shipping, including: i) financial defence of maritime assets; ii) port cost reduction and control; iii) increase in efficiency because of economies of scope; iv) customer retention and revenue stabilization; v) exploiting hub and spoke opportunities. The need for (i) the financial defence of maritime assets originates from the growing economies of scale adopted in the industry (Imai et al., 2006): due to the magnitude of investments in mega-vessels, carriers have to avoid costs related to inefficiencies and delays in terminal handling operations. By acquiring stakes in container facilities, shipping lines increase their control over the stevedoring phase. Vertical integration also enables carriers to reduce port costs in those geographic regions where terminal handling charges (THC) are too high. A direct investment in container facilities becomes a viable strategic opportunity for controlling costs, by safeguarding their bargaining power towards pure stevedores (Rodrigue and Notteboom, 2010). The involvement of shipping companies in terminal activities may be directed to pursue economies of scope or service quality and reliability by creating a port network consistent with the needs of their clients (i.e. shippers) (De Souza et al., 2003). Sometimes, investments in greenfield or brownfield projects in the container terminal domain are imposed on carriers by the lack of port infrastructures endowed by the technical characteristics coherent with their fleet (for example in terms of nautical accessibility) or organizational routine (diversion distance).

Several deep-sea companies have their own 'terminal operating holding' such as Maersk (APM Terminals) and China COSCO Group (COSCO Shipping Ports). These "hybrid operators" have changed their strategic approach towards terminal activities. In fact, they tend to manage multi-user facilities by attracting third-party carriers and generating profits. For this purpose, they often create an ad-hoc branch dedicated to port operations (Notteboom and Rodrigue, 2012).

In addition, an array of deep-sea container lines often co-operate with well-established terminal operators when setting up dedicated single-user facilities (e.g. MSC and PSA in Antwerp, Sines and Singapore) (Satta et al., 2014). Along with the carrier's perspective, a closer relationship with a terminal operator via equity partnerships in container terminal projects is expected to effectively improve carriers' business networks (Soppé et al., 2009; Parola et al., 2014). At the same time, a pure stevedore may favour the entry of one or more carriers in one of its terminals in order to establish long-term relationships and to refrain shipping companies from relocating maritime services in competing ports.

Recent empirical evidence suggests that carriers significantly rely on co-operation as an organizational option for entering the container port industry (Parola et al., 2013). By this way, they are expected to reduce costs, share risks and increase economies of scale. The growing interest by carriers in Equity Joint Ventures (EJVs) and other collaborative strategies for entering the container business, also originates from country-based institutional dimensions: in countries where port governance mechanisms have been recently reformed (e.g. China, Vietnam, etc.), Port Authorities tend to attract foreign investors by establishing EJVs where they still hold a dominant stake (Wang et al., 2004).

There exists a wide-range of port governance systems and related reforms (see Brooks and Cullinane, 2006; Brooks et al., 2017 for detailed country-based case studies). These geographical differences in governance and institutional settings combined with market characteristics and the applicable terminal tendering procedures (Pallis et al., 2008) partly shape the terminal entry strategies and opportunities for shipping lines. Based on a global dataset of containers terminals, Farrell (2012) demonstrated that container terminals in Japan and along the US West Coast are still largely controlled by shipping lines and their associated stevedoring companies, while in "landlord" ports in Europe stevedoring companies form the largest group of incumbent operators, many of them having inherited their leases or concessions from the pre-containerisation era. Global terminal operators are important in Asia and developing countries, as the previous public sector "service port" model gave local companies fewer opportunities to develop the necessary skills.

3. Research design and data collection

3.1. Operationalization of constructs and direction of causation

Based on the conceptualisation of industrial trends and the state of knowledge reported in the previous sections, the following research question is formulated:

> *RQ.1. To what extent does terminal involvement by one or more alliance members in a port result in the effective inclusion of that port as a port of call in one or more liner services of that alliance?*

To empirically answer the research question a revealed preference approach is followed, which implies an analysis of the actual behaviour of carrier groups, rather than the stated behaviour. A detection of evolutionary trends in the relation between port choice by alliance members and terminal involvement of alliance members requires data on the historical and present situations.

For the aim of the study, alternative operationalization procedures are proposed for measuring the overall involvement of members belonging to an alliance in a specific port. In particular, let P_{ij}^{t} denote the terminal involvement of one or more members of alliance i (with i = 1 to n) in a port j (with j = 1 to p) at moment t. Terminal involvement is defined as a shareholding of one or more alliance member in the terminal (minority or majority shareholding or joint venture). The construct P_{ij}^{t} can be measured in different ways:

i. Binary, i.e. there is terminal involvement of at least one of the alliance members in the port or not. In this case, P_{ij}^{t} is true or false.
ii. The number of terminals in the port in which alliance members are involved. In this case, $0 \leq P_{ij}^{t} \leq M_{j}^{t}$ with M_{j}^{t} = number of container terminals in port j at moment t.
iii. The number of alliance members involved in one or more terminals in the port. In this case, $0 \leq P_{ij}^{t} \leq A_{i}^{t}$ with A_{i}^{t} = number of members in alliance i at moment t.
iv. The equity-based terminal capacity (seaside) of the alliance members in the port. This is calculated by multiplying the shareholding of the carrier in the terminal with the total nominal terminal capacity. In this case, $P_{ij}^{t} = \sum_{l=1}^{M_j^t} \sum_{k=1}^{A_i^t} C_{klij}^{t}$ with C_{klij}^{t} = equity-based capacity of member k of alliance i in terminal l of port j at moment t (expressed in TEU)
v. The equity-based maritime terminal throughput of the alliance members in the port. Similar to the above, this gives $P_{ij}^{t} = \sum_{l=1}^{M_j^t} \sum_{k=1}^{A_i^t} T_{klij}^{t}$ with T_{klij}^{t} = equity-based maritime container throughput of member k of alliance i in terminal l of port j at moment t (expressed in TEU).

Except for measure (v.), reliable data can be found for each of these measurement units.

Analogously, let Q_{ij}^{t} denote the inclusion of port j as a port of call in the liner services of the alliance i at moment t (for a specific trade route). Also here, Q_{ij}^{t} can be measured in different ways:

vi. Binary, i.e. the port acts as a port of call for the alliance or not, in this case Q_{ij}^{t} is true or false.

vii. The number of weekly liner services in which the port is included as port of call for the alliance. In this case, $0 \leq Q_{ij}^t \leq L_i^t$ with L_i^t = number of regular liner services operated by alliance i at moment t.

viii. The total weekly capacity of the vessels operational on the liner services of the alliance and calling at the port. In this case, $Q_{ij}^t = \sum_{l=1}^{M_j^t} \sum_{s=1}^{L_i^t} V_{slij}^t$ with V_{slij}^t = the weekly vessel capacity of liner service s of alliance i calling at terminal l of port j at moment t (expressed in TEU).

ix. The total annual volumes loaded and discharged in the port using services of the alliance. In this case, $Q_{ij}^t = \sum_{l=1}^{M_j^t} \sum_{s=1}^{L_i^t} H_{slij}^t$ with H_{slij}^t = the annual volumes of liner service s of alliance i handled at terminal l of port j in year t (expressed in TEU).

Data availability for the top two measurement units (vi. and vii.) poses no real problems. Data on total weekly vessel capacities (viii) requires datasets, which provide details on the unit capacities of all vessels involved in each liner service. For example, the fleet needed to operate one weekly liner service on the Europe-Far East trade amounts to 10 to 11 ships, and ship sizes are not always homogeneous in terms of capacity. Data concerning the annual volumes generated by an alliance in the ports of call (ix) is very hard to get, given the confidential nature of individual call sizes.

Through the formulation of research question RQ.1. it is not only inferred that a causal relationship exists between the constructs P_{ij}^t and Q_{ij}^t. It also presumes a direction of causation with P_{ij}^t as the cause and Q_{ij}^t as the effect. The choice for the causality direction was influenced by considering the different time-scales of the constructs P_{ij}^t and Q_{ij}^t. Terminal involvement decisions by shipping lines (P) have a long-term impact as terminal involvement typically is fixed for many years. At the start of carrier involvement in terminals in the late 1990s, the importance of, and poor capacity situation, in key ports of call gave shipping lines a strong incentive to invest in terminals, where possible. In other words, existing port selection patterns partly guided the first terminal investment decisions of shipping lines (Cariou, 2003). Decisions on the port of calls (Q) have a short to medium-term impact: regular changes in liner service schedules take place following changes in market circumstances, alliance formation and port competitiveness. Therefore, once a decision has been made on terminal involvement, the discussion fully shifts to more operational decisions on which ports of call to include in the schedules. Most carriers have entered the terminal market more than a decade ago, so it does make sense to examine how the existing terminal participations of carriers impact port choice, not the other way around.

We propose two methodological approaches to analyse the relationship between all P_{ij}^t and Q_{ij}^t and thus to answer the aforementioned research question: one based on binary data and another relying on non-binary measurement of the constructs.

3.2. Methodological approach using binary data

The most straightforward methodological approach is to use binary data for both P_{ij}^t and Q_{ij}^t (so measures i. and vi. respectively) as this allows the extraction of a conditional statement linking P_{ij}^t to

Q_{ij}^t for all ports i and alliances j with P_{ij}^t as the antecedent and Q_{ij}^t the consequent. The research question can then be rewritten using logic analysis:

> *RQ.1 (restated). Is terminal involvement by one or more alliance members in a port a necessary and /or sufficient condition for that port to act as a port of call on one or more liner services of that alliance?*

Necessity and sufficiency are implicational relationships between conditions or states of affairs. In such an approach, concluding that P is a necessary condition for Q would imply that terminal involvement of the alliance members in the port (Q_{ij}^t) implies a status of that port as port of call in the liner services of the alliance (P_{ij}^t). In other words, if there is terminal involvement (P is true), then the consequent Q must be true if P has any chance of being true. In other words, the antecedent P cannot be true without Q being true. The issue of sufficient condition can be addressed in a similar way. **Figure 4** provides an overview of the possible combinations.

Figure 4. Possible cases based on binary data for P and Q

Case 1: P is a necessary and sufficient condition for Q

Terminal involvement of alliance i in port j (P) \ Calls in port j by alliance i (Q)	Yes (true)	No (false)
Yes (true)	a	[empty]
No (false)	{empty}	d

Case 2. P is a necessary, but not a sufficient condition for Q

Terminal involvement of alliance i in port j (P) \ Calls in port j by alliance i (Q)	Yes (true)	No (false)
Yes (true)	a	b
No (false)	[empty]	d

Case 3. P is a sufficient, but not a necessary condition for Q

Terminal involvement of alliance i in port j (P) \ Calls in port j by alliance i (Q)	Yes (true)	No (false)
Yes (true)	a	[empty]
No (false)	c	d

Case 4. P is neither a necessary nor a sufficient condition for Q

Terminal involvement of alliance i in port j (P) \ Calls in port j by alliance i (Q)	Yes (true)	No (false)
Yes (true)	a	b
No (false)	c	d

Note that a, b, c and d denote the number of observations in the total population meeting each of the respective four possible combinations of the binary values for P_{ij}^t and the binary values of Q_{ij}^t. The total population at moment t consists of all combinations of alliances i and ports j and equals a+b+c+d.

Even if all cells contained observations (i.e. case 4) the output can still be used in order to elaborate further on the relative chances that terminal involvement will lead to calls from the alliance compared to a situation in which there is no terminal involvement. To do so, we can compare a/(a+b) (i.e. the chance that Q is true when P is true) with c/(c+d) (i.e. the chance that there will be calls of the alliance at the port despite the fact that alliance members don't have a terminal involvement in the port). The bigger the gap between the two values, the more impact terminal involvement of alliance members in a port has on securing ship calls of the same carrier group.

The logic analysis based on binary data offers some room for further specifications. At the level of Q, it is possible to further decompose the analysis by specifying the minimum number of weekly calls (minimum 1, 2, 3 calls, etc.) instead of just referring to whether there are calls of the alliance or not. At the level of P, we can refine the approach by taking into account the number of alliance members that have a terminal involvement in the same port (only 1 member or 2 or more members).

3.3. Methodological approach using non-binary data

When using non-binary measures for P (measures ii. to v.) and Q (measures vii. to ix.), the possible (multivariate) analysis methods depend on the size of the dataset and the nature of the measures (ordinal, nominal, etc.). Given the small sample (i.e. 36 to 48 observations combining 3 to 4 alliances and 12 to 13 ports of call, depending on the year of observation), the non-binary empirical analysis part in this paper primarily relies on graphical techniques to assess the relationship between P and Q.

Figure 5a depicts the main graphical approach when using non-binary data for P and Q. For each alliance, the individual ports are positioned using two relative measures for Q:

- The vertical axis refers to the share of alliance i in the total number of liner services calling at port j on the analysed trade route at moment t, or mathematically $L_{ij}^{t}/\sum_i L_{ij}^{t}$ with L_{ij}^{t} = number of regular liner services operated by alliance i calling at port j at moment t. This measure refers to the relative weight of the considered alliance in the considered port of call. An elevated share points to a situation in which the alliance has a strong or even dominant position in the services calling at the considered port compared to the other alliances.
- The horizontal axis refers to the share of port j in the total number of port calls in liner services of alliance i in that specific port range and for the analysed trade route at moment t, or $L_{ij}^{t}/\sum_j L_{ij}^{t}$. This measure refers to the relative weight of the considered port of call in the liner service call pattern of the alliance considered. An elevated share implies that the considered port is a key or dominant port of call for the alliance on the trade route.

Furthermore, a two-dimensional circle is added in case the alliance members have a terminal involvement in the port. In that case, the surface of the circle is proportional to the alliance's equity-based terminal capacity in the port thus using measure (iv.) with $P_{ij}^{t} = \sum_{l=1}^{M_j^t} \sum_{k=1}^{A_i^t} C_{klij}^{t}$.

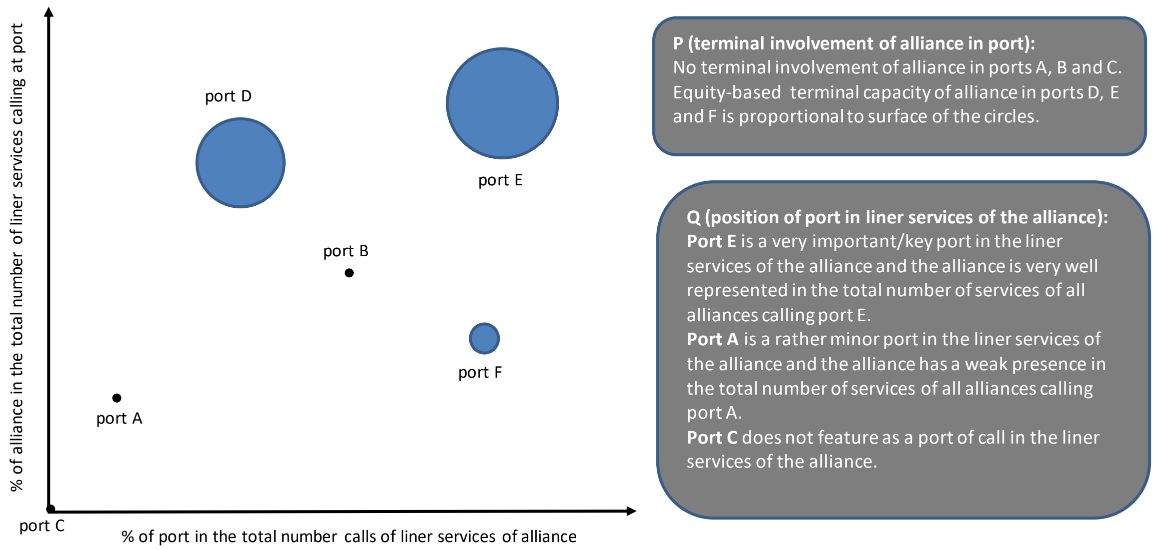
In this context, we put forward the following hypotheses for P to show a strong relationship with Q:

- H1. Only ports in which alliance members have a significant equity-based terminal capacity have a high relative share as ports of call in the liner services of that alliance (i.e. link between size of circle and the horizontal axis $L_{ij}^{t}/\sum_j L_{ij}^{t}$);
- H2. Only alliances with a significant equity-based terminal capacity in a port have a high share in the total number of calls of all alliances to that port (i.e. link between size of circle and the vertical axis $L_{ij}^{t}/\sum_i L_{ij}^{t}$).
- H3. Only ports with a significant equity-based terminal capacity of a specific alliance combine a high share of that alliance in the total number of calls of all alliances to that port and a high relative share as ports of call in the liner services of that alliance.

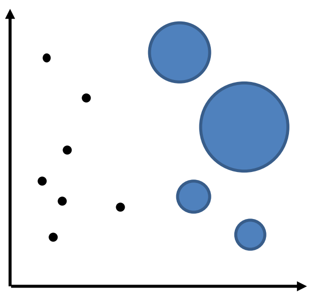
In graphical terms, H1 can be accepted if all ports with circles (particularly the larger circles) are found in the right section of the graph and all ports without circles (i.e. ports indicated by dots) are found in the left section of the graph (**Figure 5b**). In all other cases, H1 is refuted and a more nuanced discussion is needed. H2 can be accepted if all ports with circles are found in the top section of the graph and all ports without circles (i.e. ports indicated by dots) are found in the lower sections (**Figure 5c**). In all other cases, H2 can be refuted. H3 combines H1 and H2 implying that it can be accepted if ports with circles are all found in the top right section of the graph while ports without circles are only found in the other sections (**Figure 5d**).

Figure 5: Terminal involvement of an alliance and relative position of ports in the liner services of that alliance

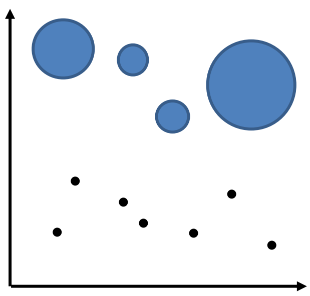
5a. Overall presentation



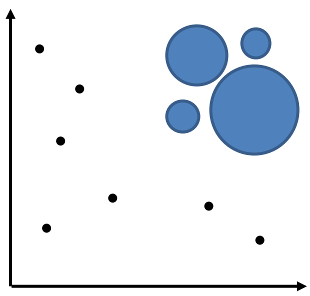
5b. H1 accepted



5c. H2 accepted



5d. H3 accepted



3.4. Data collection

The empirical application focuses on alliances' choice of ports of call on the Europe-Far East trades, more particularly on North-West European ports of call in the Hamburg-Le Havre range, the UK and the Baltic.

The dataset contains the following details:

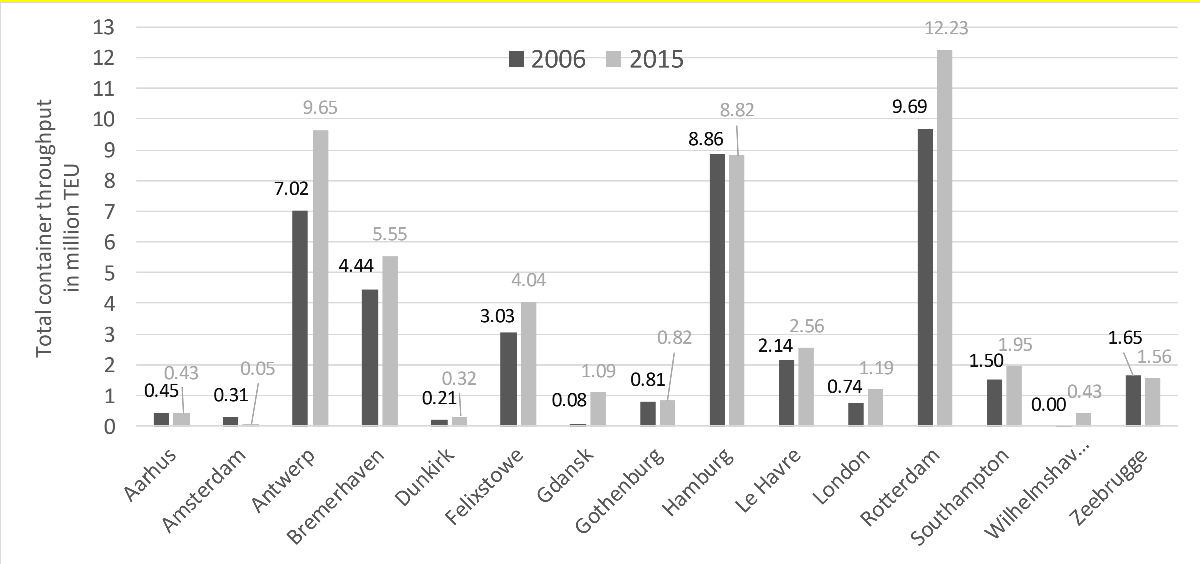
- The number of weekly calls per NW-European port of call for the alliances active on the North Europe-Far East route. We only considered the liner services jointly operated by existing alliances. Liner services offered by stand-alone operators were left out. Data on liner service patterns were obtained from carrier websites. Historical data on liner services were obtained from own research archives on liner shipping;

- The involvement in terminals in NW-Europe by carriers belonging to existing alliances. Data were collected on the terminal ownership structure for each of these terminals and the capacity of the terminals concerned. In line with measure (iv.) for P, the equity-based terminal capacity of each carrier in each NW-European container terminal was used. Terminal capacity data were obtained via the annual Drewry reports on global terminal operators (Drewry, 2016b) and, where needed, adjusted and updated using websites and information from specialised press.

Data was gathered for Q2 2006, Q2 2015 and Q2 2017. These periods were chosen for a number of reasons. First, the landscape in terms of alliances looked very different in these three periods of observation, i.e. Grand Alliance, New World Alliance and CKYH were operational in 2006, CKYHE, 2M, Ocean Three (O3) and G6 in 2015 and 2M, THE Alliance and Ocean Alliance in 2017 (see Figure 3). These very different carrier alliance settings add value to the comparison of the outcomes per year of observation. Second, terminal involvement of liner shipping companies in NW-European ports took off in the late 1990s and early 2000s.

The dataset only contains NW-European seaports that were ports of call on at least one Europe – Far East liner service during the period of observation. Container ports, even larger ones such as Liverpool, which have never received vessel calls on the Europe – Far East trade were excluded. Taking into account this consideration, **Figure 6** provides an overview of the total container throughput (both deep-sea and feeder/short-sea) in the ports included in the dataset. It can be observed that the dataset not only includes very large container ports such as Rotterdam, Hamburg and Antwerp, but also a range of medium-sized and smaller container ports. The majority of the established container load centres experienced valuable growth rates between 2006 and 2015. A few medium-sized to large ports are witnessing a small traffic decline in the period of observation (e.g. Hamburg and Zeebrugge). Some of the ports in the dataset entered the deep-sea container market after 2006 (e.g. Wilhelmshaven in Northern Germany and Gdansk in Poland) while Amsterdam completely lost its role in the deep-sea market since 2012.

Figure 6: Total container throughput in 2006 and 2015 for the selected ports



Source: author's compilation based on data provided by port authorities

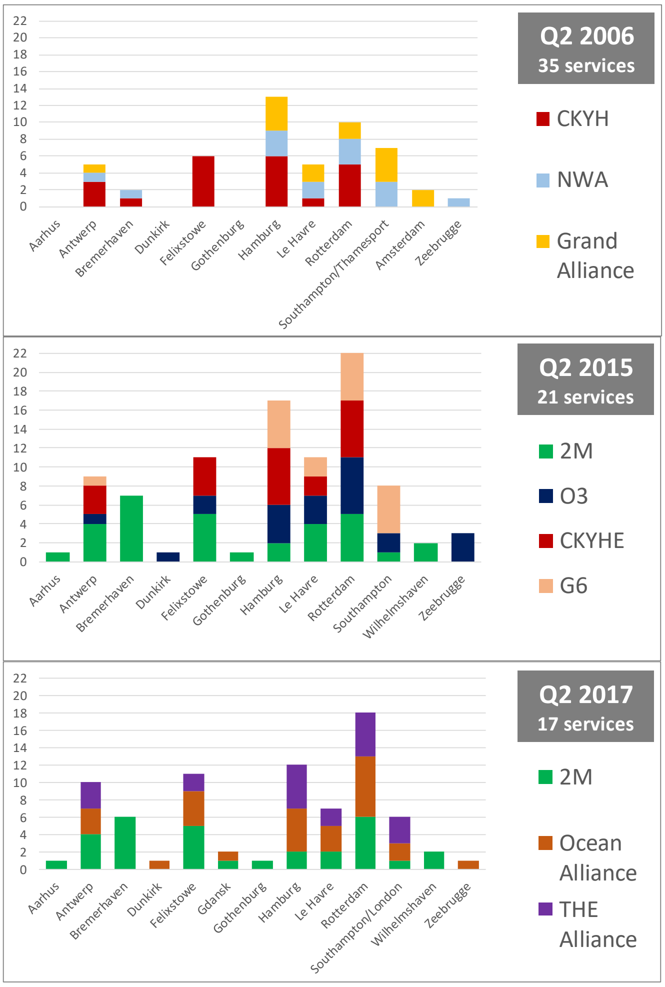
4. Empirical findings

4.1. Base data

Figure 7 provides an overview of the number of calls per port using services offered by the then existing alliances on the Europe-Far East trade route. We note that in 2015 and 2017 the alliances were the only providers of regular liner services on this trade route while in 2006 there were quite a few independent operators offering services as well (such as Maersk Line, MSC, and Evergreen). The latter services are not included in the figures for comparison reasons. It can be concluded that Rotterdam and Hamburg receive most direct weekly calls throughout the period of observation, followed by Antwerp and a number of UK ports. Quite a few ports only received vessel calls of one alliance operational on the Europe – Far East trade. The most striking example is the port of Bremerhaven, which welcomed 6 to 7 weekly calls from 2M (i.e. Maersk Line and MSC) in 2015 and 2017, but no calls from other alliances.

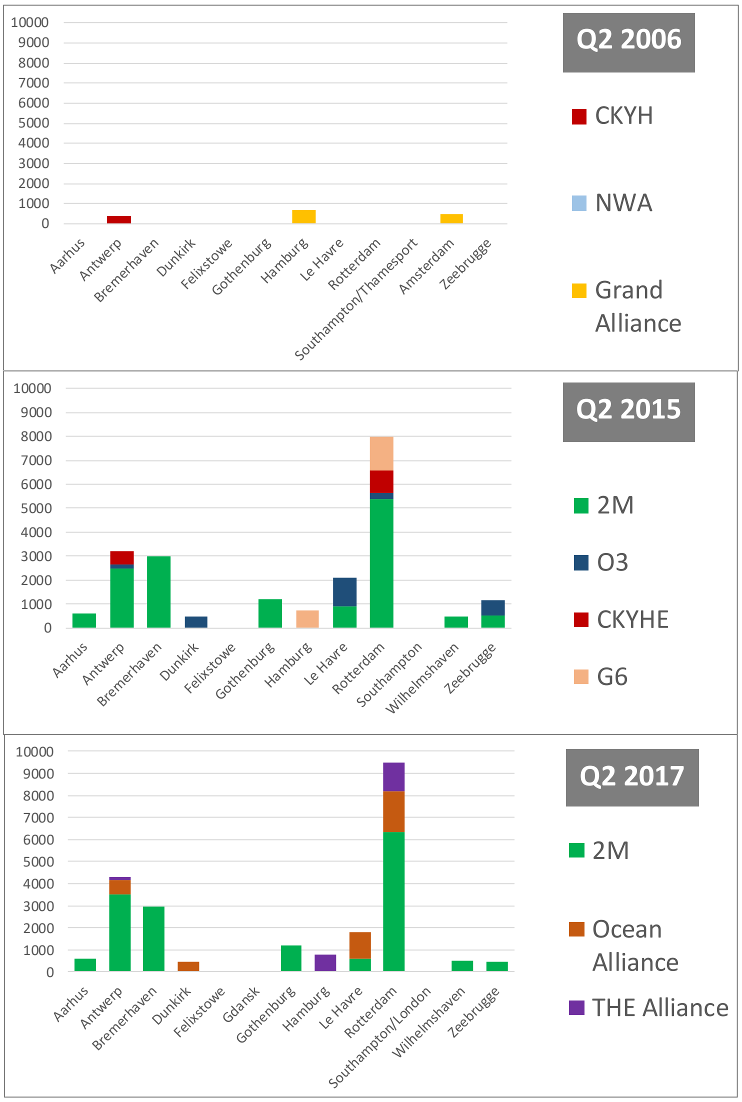
Figure 8 summarizes the collected information on the involvement of alliance members in terminals. As mentioned earlier, we use the equity-based terminal capacity, partly because it was not feasible to collect reliable throughput data for the respective terminals. It involves formal forms of terminal involvement such as minority and majority shareholdings and joint ventures. The involvement can be direct or indirect via a sister company or subsidiary specialised in terminal operations (e.g. Cosco Shipping Ports, Terminal Link, APM Terminals).

Figure 7. Number of weekly calls of vessels operational on NW Europe-Far East services per alliance and port of call (double calls possible)



In 2006, the existing alliances only had a few terminal investments in NW-Europe. The Grand Alliance was the most active with NYK as full owner of the only deepsea terminal in Amsterdam and Hapag-Lloyd having a 24.49% shareholding in the Altenwerder Container terminal in Hamburg (with the remainder of the shareholding in the hands of local operator HHLA). MSC and Maersk Line already had terminal participations in 2006, but as these leading carriers were still operating independently these figures were not included in the alliance-focused analysis. In 2015, the 2M members had terminal involvements in 8 ports with most equity-based terminal capacity in Rotterdam followed by Antwerp and Bremerhaven. The Ocean Three was involved in 5 ports, mainly through Terminal Link in which alliance member CMA CGM has a 51% ownership. The CKYHE and G6 alliances had the smallest terminal involvement covering only two ports each. In 2017, 2M remained active in terminals in 8 NW-European ports with particularly Rotterdam and Antwerp seeing a rise in equity-based terminal capacity figures compared to 2015. The Ocean Alliance had terminal stakes in 4 ports with Cosco Shipping Ports having minority stakes in the Euromax terminal in Rotterdam and the Antwerp Gateway terminal in Antwerp, and CMA Terminals and Terminal Link (both associated with alliance member CMA CGM) active in Rotterdam, Antwerp, Dunkirk and Le Havre. 'THE Alliance' members only have terminal stakes in Hamburg and Rotterdam.

Figure 8. Equity-based terminal capacity (in 1000 TEU) controlled by alliance members

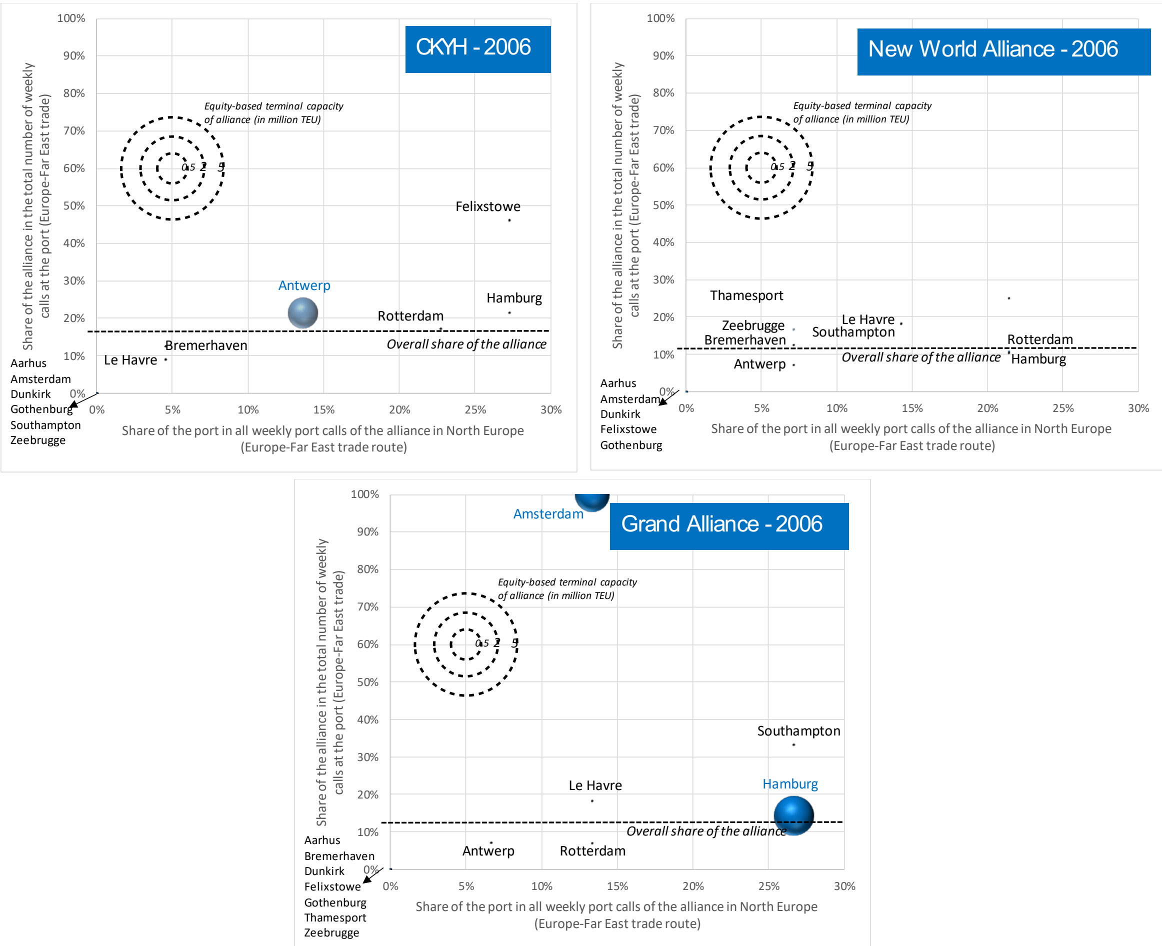


4.2. Analysis based on non-binary data

Figures 9 to 11 provide the alliance-based results for Q2 2006, Q2 2015 and Q2 2017 using the presentation method discussed in Figure 5a. The most important overall conclusion is that the graphs based on non-binary data provide clear indications that there is no alliance for which hypotheses H1, H2 and/or H3 can be accepted. Still, the results provide valuable insights on the relationship between P and Q for each of the alliance groups.

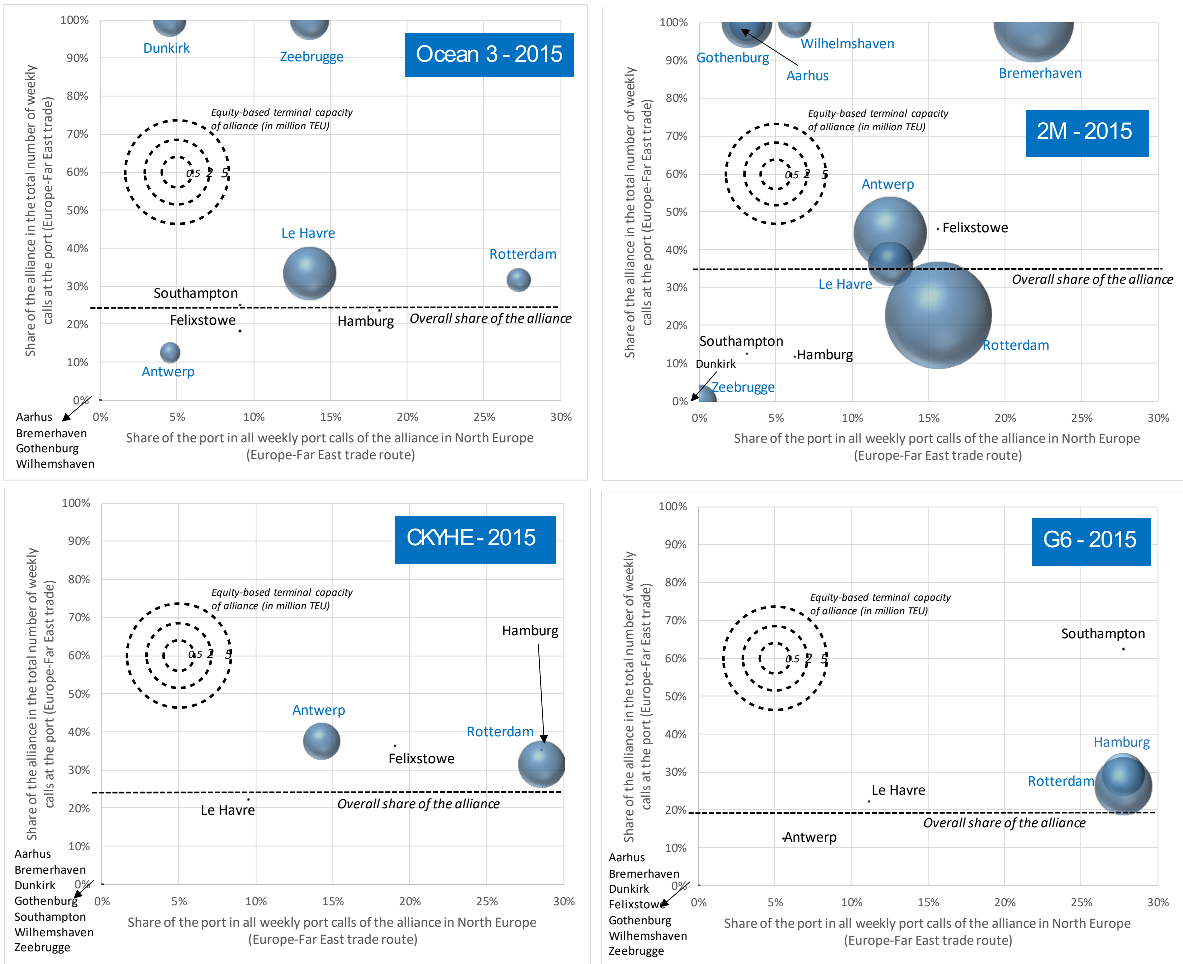
In 2006, the overall terminal involvement of alliance members was low. For CKYH, the small terminal participation in Antwerp did not seem to result in a strong relative position of Antwerp in the alliance's liner services on the Europe-Far East trade, leading us to refute all posed hypotheses for this alliance (**Figure 9**). Hamburg and Southampton show the same relative importance in the service network of the Grand Alliance, but there is only a terminal involvement in Hamburg. The same applies to Amsterdam and Le Havre, with the former seeing terminal ownership by the alliance member NYK and the latter not. For these and other reasons, H1, H2 or H3 cannot be accepted in case of the Grand Alliance.

Figure 9. Terminal involvement of alliances and relative position of ports in the liner services of these alliances – Q2 2006



The graphs for Q2 2015 lead to some interesting findings (**Figure 10**). In the case of Ocean Three, none of the hypothesis can be accepted. There clearly is no evidence at all to accept H1 or H3. It would be possible to accept H2 were it not for the position of the port of Antwerp. In other words, in all but one case (i.e. Antwerp), the share of Ocean Three in the total number of services calling at the port is higher in case of terminal involvement than in case of an absence of terminal involvement. In the case of Dunkirk and Zeebrugge, Ocean Three is the only alliance calling at the port and combines this with partial terminal ownership.

Figure 10. Terminal involvement of alliances and relative position of ports in the liner services of these alliances – Q2 2015



For the 2M (Maersk Line and MSC), H1, H2 and H3 also have to be refuted, only because of the somewhat 'atypical' positions of Felixstowe and Zeebrugge in Figure 10. Felixstowe is a key port of call for 2M (i.e. 16% of all its weekly calls in NW European ports on the Europe-Far East trade) and the alliance has a strong position in this port representing some 45% of all weekly Far East services calling Felixstowe. Still, the 2M members do not have any terminal involvement as the container handling facilities in Felixstowe are fully controlled by Hutchison Port Holdings (HPH). This raises the question whether 2M has made attempts in the past to enter the terminal scene in Felixstowe (via minority shareholding or JV). Such a step seems to be logical given the involvement of the alliance members in all the other key ports of call. Also Zeebrugge is an atypical port for 2M: as we shall demonstrate later in the binary-based analysis, this is one of the few cases in the entire dataset where an alliance has terminal involvement in a port (P is true) but the port receives no calls on the Europe-Far East trade (Q is false). It is worthwhile to mention that 2M has a terminal involvement in all ports of call which are not visited by the other alliances (value 100% on the vertical axis). This might imply that 2M is actively following a strategy of combining terminal ownership and vessel calls in ports in which other alliance members are absent on the Europe-Far East trade, i.e. Aarhus, Gothenburg, Wilhelmshaven and Bremerhaven. As mentioned, also Ocean Three seems to follow a similar logic with regard to Dunkirk and Zeebrugge.

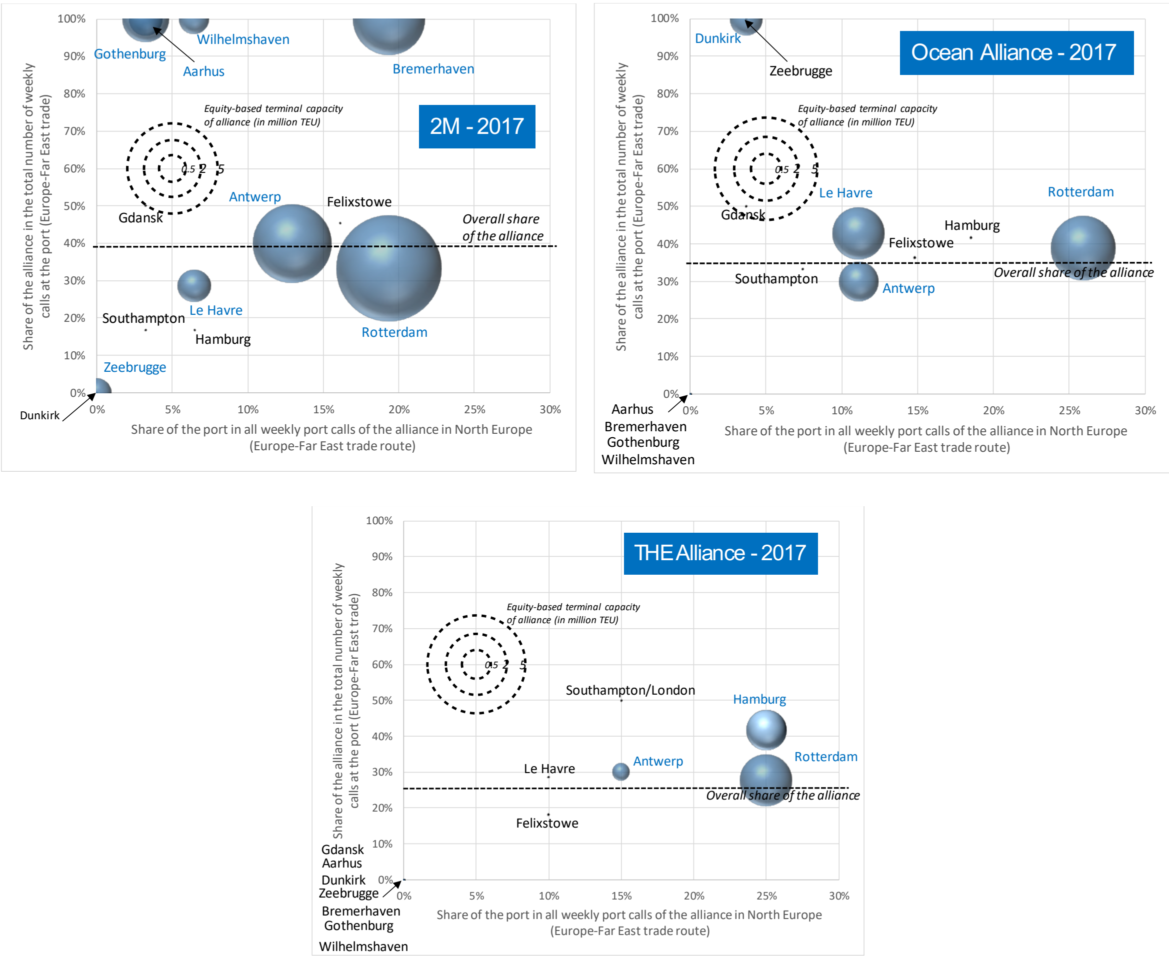
The CKYHE was only involved in terminals in Antwerp and Rotterdam, but a closer examination of the graph leads to the conclusion that none of the hypotheses can be accepted. The positions of Felixstowe and Hamburg are fairly similar to Rotterdam and Antwerp, despite a lack of active terminal participation in the two former ports. This brings us back to the early discussion of the relative accessibility of ports to foreign carriers. The case of HPH in Felixstowe was mentioned earlier. The case of Hamburg needs further elaboration: except for German carrier Hapag-Lloyd no other carrier has ever been able to secure a shareholding in a local container terminal. All large container handling facilities in Hamburg are operated by terminal operating groups with a very strong German interest, i.e. HHLA and the German/Italian group Eurogate. Even smaller multi-purpose terminals are in German hands such as Unikai and Rhenus. These observations seem to suggest that an institutional factor is at play, i.e. a strong national orientation in Hamburg when it comes to terminal ownership, making it more difficult or even impossible for foreign international terminal operators (ITOs), including carrier-related ones, to obtain a foothold in Hamburg's terminal market. As a revealed preference approach is followed, carriers' attempted entries into ports such as Felixstowe and Hamburg were not recorded. Even if that information were to be included, it is not possible to detect whether carrier groups have tried to enter these markets in the past given the confidential nature surrounding possible terminal M&A discussions and the bidding procedures in the framework of container terminal concessions.

The results for the G6 provide evidence to refute H2 and H3. If it were not for Southampton, it would have been possible to accept H1. Southampton is a private port controlled by the Dubai-based group DP World, one of the main carrier-independent global terminal operators. The same ITO also developed the London Gateway terminal in recent years into a fast-growing UK gateway. It is striking that there are no terminal involvements of alliances in any of the key UK container ports active on the Europe-Far East trade (i.e. Felixstowe, Southampton and London).

The results for 2M in Q2 2017 are fairly similar to 2015 (**Figure 11**). H1, H2 and H3 are also refuted in the case of the Ocean Alliance. Felixstowe and Hamburg are both vertically positioned between three ports in which the alliance members have a major terminal involvement (i.e. Rotterdam, Antwerp and Le Havre) making it not feasible to accept H1. The refuting of H2 is obvious given the positions of Zeebrugge, Gdansk, Hamburg, Felixstowe and Southampton in comparison to Antwerp, Rotterdam and Le Havre. The situation for 'THE Alliance' almost leads to the acceptance of H1 was it not for the position of Southampton/London Gateway. Once again, the lack of terminal involvement in a UK port prohibits to accept one or more of the hypothesis. Le Havre joins Southampton/London in preventing acceptance of H2 and H3.

In summary, the results based on non-binary data do not point to a clear cut direct relationship between P and Q. The general lack of terminal interests of alliance members in Hamburg and UK ports in many cases prevents acceptance of H1 and/or H2. The 2M is the only carrier combination coming rather close to the situation captured by H3, but Zeebrugge and Felixstowe are the atypical cases forcing us to refute H3 also in that case.

Figure 11. Terminal involvement of alliances and relative position of ports in the liner services of these alliances – Q2 2017



4.3. Logic analysis based on binary data

The analysis of non-binary data provided some important clues concerning the relationship (or lack thereof) between P and Q. In this section, the discussion is extended and the findings refined by adding a logic analysis layer based on binary data. The methodological base for this approach was explained in Section 3.2.

Table 1 presents the main results of the logic analysis. In the first case (base case), Q is a binary value (true or false) referring to whether or not the alliance calls at the port in the framework of its schedules liner services on the North-Europe – Far East trade. In the second and third cases, Q refers to a minimum of weekly vessel calls to the port, i.e. 2 and 4 respectively. In cases 1 to 3, P is a binary value expressing whether the alliance members have a terminal interest in the port or not.

Table 1
Logic analysis for relationship between P and Q for different years and different variations on the meaning of P and Q.

	No. of observations	I.	II.	III.	IV.	Total	I. + II.
		P = true, Q = true	P = false, Q = false	P = false, Q = true	P = true, Q = false		
Q = min 1 weekly call by alliance P = terminal involvement of 1 or more alliance members							
(1A) Q2 2006 – all alliances	36	8.3%	47.2%	44.4%	0.0%	100.0%	55.6%
(1B) Q2 2015 – all alliances	48	33.3%	39.6%	25.0%	2.1%	100.0%	72.9%
(1C) Q2 2017 – all alliances	39	35.9%	30.8%	30.8%	2.6%	100.0%	66.7%
Q = min 2 weekly call by alliance P = terminal involvement of 1 or more alliance members							
(2A) Q2 2006 – all alliances	36	8.3%	63.9%	27.8%	0.0%	100.0%	72.2%
(2B) Q2 2015 – all alliances	48	25.0%	43.8%	20.8%	10.4%	100.0%	68.8%
(2C) Q2 2017 – all alliances	39	28.2%	41.0%	20.5%	10.3%	100.0%	69.2%
Q = min 4 weekly call by alliance P = terminal involvement of 1 or more alliance members							
(3A) Q2 2006 – all alliances	36	2.8%	80.6%	11.1%	5.6%	100.0%	83.3%
(3B) Q2 2015 – all alliances	48	16.7%	54.2%	10.4%	18.8%	100.0%	70.8%
(3C) Q2 2017 – all alliances	39	15.4%	53.8%	7.7%	23.1%	100.0%	69.2%
Q = min 4 weekly call by alliance P = terminal involvement of 2 or more alliance members							
(4) Q2 2017 – all alliances	39	10.3%	69.2%	12.8%	7.7%	100.0%	79.5%

Q is a necessary and sufficient condition for P when both P and Q are either true or false for the entire population. This condition is not met in any of the observed results for cases 1A to 4. The combined share of observations that comply with the statement that P and Q are either true or false in the total number of observations reaches between 55% and 83% depending on the case (see the last column in table 1). In cases 1A and 2A terminal involvement of the alliance in a port (P) is a sufficient condition for that port to receive liner services, but not a necessary condition. In other words, in these two cases dating back to Q2 2006 having terminal interests of alliances always guarantees vessel calls of these alliances, but in respectively 44.4% and 27.8% of the observations calls are also made even without a terminal involvement of the corresponding alliance. Except for cases 1A and 2A, there are always few cases where terminal involvement of an alliance in a port does not result in vessel calls of that alliance in that port (see column IV).

In case 4 the meaning of P is slightly changed to capture whether or not at least two alliance members have a terminal involvement in the port. When comparing the results of case 3C with case 4, it can be observed that in 79.5% of the observations of case 4 P and Q are either true or false. This figure amounts to 'only' 69.2% in case 3C. This seems to indicate that if at least two members have a terminal involvement in the same port, there will be a stronger pressure exerted on all alliance members to include the port in the liner service schedules and to send more weekly liner services to that port. If only one alliance member has a terminal interest in the port then he has to convince the other members of the value of calling at the port.

Table 2 further elaborates on the values presented in the last column of table 1 by presenting the sub-results per alliance active during the years of observation. It can be concluded that for only one alliance there is a one-on-one match between P and Q: only ports in which the members of the New World Alliance had a shareholding received at least four weekly calls of the alliance on the Europe-Far East trade. In all other cases and for all other alliances the condition that Q is a necessary and sufficient condition for P is not met.

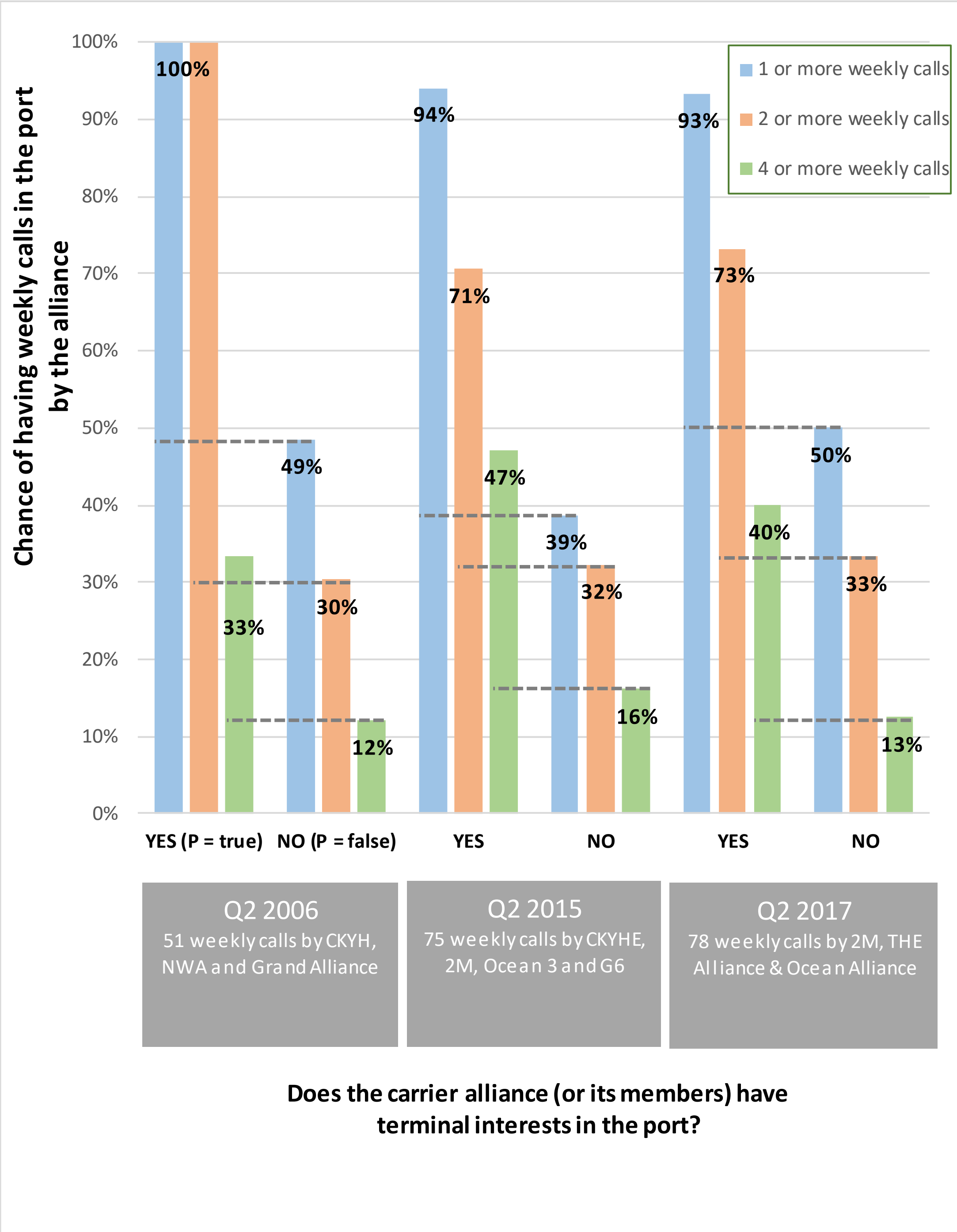
Table 2
Share of observations that comply with condition {P = true and Q = true} or {P = false and Q = false} – results for all alliances and each alliance separately.

	All alliances	CKYH	New world alliance	Grand alliance	Ocean three	CKYHE	G6	2M	Ocean alliance	THE alliance
Q = min 1 weekly call by alliance										
P = terminal involvement of 1 or more alliance members										
(1A) Q2 2006	55.6%	58.3%	41.7%	66.7%	–	–	–	–	–	–
(1B) Q2 2015	72.9%	–	–	–	75.0%	75.0%	75.0%	66.7%	–	–
(1C) Q2 2017	66.7%	–	–	–	–	–	–	61.5%	61.5%	76.9%
Q = min 2 weekly call by alliance										
P = terminal involvement of 1 or more alliance members										
(2A) Q2 2006	72.2%	75.0%	66.7%	75.0%	–	–	–	–	–	–
(2B) Q2 2015	68.8%	–	–	–	58.3%	75.0%	83.3%	58.3%	–	–
(2C) Q2 2017	69.2%	–	–	–	–	–	–	61.5%	69.2%	76.9%
Q = min 4 weekly call by alliance										
P = terminal involvement of 1 or more alliance members										
(3A) Q2 2006	83.3%	66.7%	100.0%	83.3%	–	–	–	–	–	–
(3B) Q2 2015	70.8%	–	–	–	58.3%	75.0%	91.7%	58.3%	–	–
(3C) Q2 2017	69.2%	–	–	–	–	–	–	53.8%	61.5%	92.3%
Q = min 4 weekly call by alliance										
P = terminal involvement of 2 or more alliance members										
(4) Q2 2017	79.5%	–	–	–	–	–	–	76.9%	76.9%	84.6%

Referring to figure 4 in section 3.2, it is possible to elaborate on the relative chances that terminal involvement will lead to calls from the alliance compared to a situation in which there is no terminal involvement. **Figure 12** compares the chance that Q is true when P is true with the chance that there will be calls of the alliance at the port despite alliance members do not have a terminal involvement in the port. The bigger the gap between the two values, the more impact terminal involvement of alliance members in a port has on securing ship calls of the same carrier group.

The results demonstrate that ports have a much higher chance of receiving calls of an alliance when the alliance members have a terminal stake in the port. If a carrier alliance has a stake in a northwest European port, the chance of receiving at least one weekly call on the Europe-Far East trade ranges from 93% to 100% for the periods considered. The 100% value in Q2 2006 indicates that P is a sufficient but not a necessary condition for Q in that year which is in line with the results of Table 1. Without terminal involvement, the chance of receiving a weekly call drops to about 50%. In case Q involves a higher minimum number of weekly calls by the alliance, the chances of receiving direct calls also drop significantly, i.e. from a 71%-100% range with terminal involvement to a 30-33% range without terminal involvement in case of at least two weekly calls and from a 33%-47% range to only 12-16% in case of four or more weekly calls. Figure 12 demonstrates that the chances have not significantly altered over time despite major changes in alliance formation, the reduction in the number of scheduled weekly services on the Europe-Far East trade and the increases in vessel size. Obviously, some differences between Q2 2006, Q2 2015 and Q2 2017 can be observed, but the overall gaps between the situations with and without terminal involvement remain of a similar magnitude and do not point to major shifts taking place in how terminal involvement affects the chances of receiving vessel calls.

Figure 12. Chance of having weekly calls in the port by the alliance as a function of terminal involvement of alliance members in the port (binary data – NW-European ports of call - liner services on Europe-Far East trade)



5. Conclusions

The literature on port choice/selection by carriers refers to the formal terminal interests of carrier groups as one of the many potential factors affecting liner service design and the decisions made as regards port calling patterns. This study is the first to empirically examine the complex link between the involvement of carriers in terminals and the inclusion of ports in the liner service schedules of the alliance in which the carriers are involved.

We first conceptually positioned terminal involvement and alliance formation in one of the four groups of port selection criteria. Then, the paper presented two methodological approaches to answer the research question: *to what extent does terminal involvement by one or more alliance members in a port result in the effective inclusion of that port as a port of call in one or more liner services of that alliance?* The different time-scales of the two constructs supported the presumed direction of causality. Both methodological approaches (i.e. one based on binary data and another on non-binary data) were applied to liner services operated by carrier groups on the Europe-Far East trade, with a specific focus on the ports of call in the NW-European container port system. Data was collected for Q2 2006, Q2 2015 and Q2 2017, i.e. significant years in which the landscape in terms of alliance formation looked very different.

Three hypotheses on the presumed relations between P and Q formed the basis for the analysis using non-binary data. However, the graphical analysis showed that none of the hypotheses could be accepted, no matter the year of observation or the alliance under consideration. In quite a few cases the acceptance of one or more hypotheses was obstructed by the situation in a number of ports (mostly UK ports and Hamburg) having no terminal involvement despite being important to the alliance. This raises the question on how accessible these ports are to the entry of foreign carrier-based terminal operators. Indeed, there are no terminal involvements of alliance members in any of the key UK container ports active on the Europe-Far East trade (i.e. Felixstowe, Southampton and London). The adoption of the private port management model in UK ports resulted in the entry of foreign multi-user international terminal operators (ITOs) such as HutchisonPorts and DP World while carrier-linked terminal groups remain absent. Conversely, landlord port Hamburg seems to exert a strong national orientation when it comes to terminal ownership, making it more difficult or even impossible for foreign ITOs, including carrier-related ones, to enter Hamburg's terminal market. Thus, the opportunities for carrier-based terminal operators to enter the terminal business differ among ports, even within the same region (i.e. NW-Europe). The potential strategic reach of this objective observation requires further research. This would need further insight into the (unsuccessful) attempts of carriers to enter the terminal market of these ports. While such a more qualitative analysis would certainly add value to our findings, we expect that it is very difficult to get the necessary base information given the confidential nature surrounding terminal M&A discussions and the bidding procedures in the framework of container terminal concessions.

Another remarkable finding is that in one specific case (i.e. 2M and Zeebrugge) terminal ownership of alliance members does not guarantee even one weekly call on the NW-Europe Far East trade. Such observation raises questions on the long-term sustainability of the terminal involvement of 2M in Zeebrugge, particularly considering the port's sharp decline in container volumes in the past few years.

While the results based on non-binary data did not point to a clear cut direct relationship between P and Q, the logic analysis based on binary data provided more detailed insights on this presumed relationship. First, in only a few cases terminal involvement of an alliance in a port does not result in vessel calls of that alliance in that port. If at least two members have a terminal involvement in the same port, there will be a higher chance of receiving many vessel calls of the alliance then in case only one alliance member has a terminal stake.

The most explicit proof of a direct relationship between P and Q was found when calculating and comparing relative chances of a port to receive vessel calls by an alliance. We clearly demonstrated in a quantitative manner that ports have a much higher chance of receiving calls of an alliance when the alliance members are having a terminal stake in the port. This conclusion remains standing if we increase the minimum number of weekly calls by the alliance. Another relevant conclusion is that no major shifts have taken place during the period of observation in how terminal involvement affects the chances of having vessel calls. This relative stability in the relationship between P and Q is a fact despite major changes in alliance formation, the reduction in the number of scheduled weekly services on the Europe-Far East trade and the increases in vessel size.

Empirically testing the role of inter-carrier dynamics and terminal interests of carriers in explaining the calling pattern behaviour of these shipping lines, the paper has also value to port managers and shipping professionals in view of port strategy and planning decisions and shipping strategy formulation.

At the same time, it opens avenues for further research. The findings are valid for the container ports in NW-Europe and the Europe-Far East services connected to this port system. We do not claim that the results are valid on a global scale. Differences in port governance systems and reform, terminal tendering procedures and local market conditions can have an impact on the investment strategies of and opportunities for carrier-based terminal operators. An extension of the dataset to include other regional port systems (e.g. the Med, Far East, West Coast North America) and liner services on other trade routes in which alliances are active (e.g. the trans-Pacific trade) would help to validate and extend the findings. Given regional differences in carrier involvement in ports (partly resulting from variations in local/regional port governance systems and entry barriers, and regional market circumstances – see: Ferrari et al 2008 and Notteboom and Rodrigue, 2012), we expect such an extension of the analysis will result in a more differentiated picture of the presumed relations between P and Q. It is also expected to bring forward some regional components in the strategic behaviour of alliances with respect to service patterns and terminal assets.

It would also be worthwhile to further investigate which are the strategic, institutional and operational factors that might explain why no terminal involvement of alliance members can be found in some key ports in their network.

The analysis solely focused on formal terminal ownership of alliance members through shareholdings or joint ventures. We are aware that some independent terminal operators are providing operational benefits to large customers such as alliances. Priority berthing arrangements for ships of the alliance are a typical example. These benefits can approach the operational benefits obtained in case of partial or full terminal ownership. While the collection of information on this issue might prove to be troublesome, it is interesting to develop more qualitative research in view of exploring to what extent such (far-reaching) operational arrangements in key ports might lower the incentive for carriers to pursue a formal shareholding in terminals of these ports of call.

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