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Patterns of maritime supply chains: slot capacity analysis

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ABSTRACT

This paper offers a tool for analysing patterns of maritime supply chains. The study uses empirical data on slot capacity deployed by container shipping lines for analysing ports (as nodes) and routes and shipping lines (as links) that are embedded within the maritime supply chain. The ports of Singapore and Hong Kong are chosen to illustrate the respective transhipment and gateway perspectives. Findings reveal that geographical location and changes in the constitution of players can have reverberations on the maritime supply chain dynamics that traverse the port. Furthermore, evidence from trade route data also shows that maritime supply chain dynamics associated with transhipment and gateway ports could be governed by different levels of scope economies, demand complementarity and market power. The paper illustrates the abundant potential of slot capacity analysis for academic and industry/market research. Thus, future research can be pursued in various contexts and for different applications.

1. Introduction

A global distribution channel with a reliable transport system is essential in the contemporary world economy. Freight transport contributes to the sustainability of the transport system through its impact upon the economic, social and environmental well being of nations (Norojono and Young, 2003). Maritime transport is a dominant mode as over 90% of global trade volume is carried by sea (IMO, 2008). Historically, the role of seaborne trade has been the backbone of economic development. This has been sufficiently established by the fact that major cities and industries have developed in coastal locations to take advantage of shipping. The manufacturing industry in global supply chains depends on maritime transport services both in inbound and outbound logistics. Therefore, shipping is a vital component in global supply chain management. Shipping plays an important role in providing low-cost and efficient transportation. It is also environmental friendly relative to other modes of transport. Apparently, acting as trade facilitators, carriers and seaports are important players in the system.

Traditionally, maritime transport comprised a well defined series of related but separated activities, with each participant being responsible for a limited part of the process. Manufacturers, distributors, shippers, freight forwarders, carriers, terminal operators and truckers all specialised in their individual roles. Graham (1998) notes that the maritime transport business is characterised by fragmentation of operating units and a requirement for intensive network control.

However, this mode of operation is no longer sufficient in managing global supply chains competitively in the modern era. Since its advent in the mid-1960s, containerisation has been responsible for integration within the transport chain (Brooks, 2000). In recent years, the industry is progressing towards a lower degree of fragmentation. Different forms of integration occurred. Various players in the supply chain work together to smooth both cargo and information flows. Also some major ocean carriers attempt to provide total supply chain solutions to their customers. More and more ports and terminal operators position themselves as a platform connected to the various supply chain parties. The increasing industry trend is to assume a more integrated approach.

Not many studies have been undertaken to address supply chain integration in maritime transport, notwithstanding its significance in the global economy. Therefore, this paper examines container shipping from an integrated perspective and specifically investigates the topic of maritime supply chains, which is a relatively new research area. The paper aims to demonstrate a tool for analysing patterns of maritime supply chains. It uses empirical data on slot capacity deployed by container shipping lines (i.e. cargo-carrying capacity of vessels) for analysing ports (as nodes) and routes and shipping lines (as links) that are embedded within the maritime supply chain. More specifically, the paper has chosen the ports of Singapore and Hong Kong to illustrate the transhipment and gateway perspectives. Here the maritime supply chain in the context of container shipping is defined as *the connected*

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series of activities pertaining to shipping services which is concerned with planning, coordinating and controlling containerised cargoes from the point of origin to the point of destination. Shippers, shipping lines and ports in the chain are vertically linked by customer–supplier relationships and are our primary focus in this study.

2. Literature review

The significance of supply chain management on the maritime business is acknowledged in the literature. Some papers address either shipping lines or ports, and study how they relate to the rest of the supply chain (for example, Evangelista and Morvillo, 1999, 2000; Robinson, 2002; Paixao and Marlow, 2003; Bichou and Gray, 2004; Weston and Robinson, 2005; Fremont, 2006). For the current study on maritime supply chains, examining a vertically integrated approach linking the various members and elements would advance our understanding of the network. In this respect, there are mainly four prior studies explicitly addressing supply chain integration in the maritime transport context, which will be reviewed in this section.

The first one is that by Frankel (1999). He states that integrating the various elements of a supply chain can offer economies in the following aspects: cost; supply chain capacity; management; equipment inventory owning, holding and use; information and communication systems; and facility requirements. Supply chain deviations crucially impact supply chain performance, so reducing link uncertainties and risk can achieve significant improvements in cost, profitability as well as market outreach in an increasingly globalised world. Thus, an integrated approach in trans-ocean transport is needed.

Islam et al. (2005) suggest that multimodal freight transport can act as a catalyst for removing trade barriers. They use Bangladesh as a case and point out various barriers in a fragmented freight transport system such as lack of standardization, lack of trust, commitment and cooperation, inadequate access and use of information systems, and passive role played by the government. Therefore they present a normative model for efficient goods movement promoting supply chain integration in which all shippers and consignees have access to door-to-door services from factory premises to port or through inland clearance depots for developing economies.

Lam (2006) proposes a model of achieving excellence in container shipping supply chains. She addresses better synchronisation of the functions and the major partners involved, namely, shipper, shipping line, and container port/terminal operator. The study employs the total cost concept derived from management theory, and economies of scope and demand complementarity for illustration and application in practice. The discussions are related to the cost incurred, the revenue created and hence the profit generated by the chains.

Notteboom and Rodrigue (2008) discuss the challenges to the world container system using a systems approach. They examine the critical issues of liner services, ports and terminals, and inland distribution. In dealing with global supply chains, they suggest that a multiplication of service network types would provide the best value attributes; the development of multi-port gateway regions will become more important; inland freight distribution, especially the repositioning of empty containers will continue to be a key logistical challenge.

In terms of the methodology of slot capacity analysis employed by the current study, three previous papers also adopt the approach of slot capacity data deployed by container shipping lines. Yap et al. (2006) use slot capacity to analyse container port competition in East Asia. The paper examines the changes in slot capacity connected to the major ports. Fremont (2007) analyses the configuration of containerised maritime networks. Slot capacity data is used to conduct a case study of Maersk Line. Lam and Yap (2008) illustrate that slot capacity data can be categorised by revealing what are the volumes for parallel calls and exclusive calls at the ports in the study. The presence, extent and development of port competition can be determined by the levels and changes of slot capacity connected. Particularly, this paper discusses competition for transhipment containers among the ports of Port Klang, Singapore and Tanjung Pelepas.

Collectively, the cited studies demonstrate that slot capacity analysis can generate insightful information to reveal port competition and liner network dynamics. This paper takes a different tack by suggesting that the method can also be useful for analysing the patterns of maritime supply chains.

3. Research methodology

Data for shipping services deployed by container lines (Informa, 2000–2006) is used to derive slot capacity deployed in terms of twenty-foot equivalent unit (TEU), which is calculated by the following formula:

$$Y_t = \sum_{k=1}^{n} y_{ij}^{kt} \tag{1}$$

where Y_t is the total slot capacity of k shipping services for the time period t, deployed between port i and port j for $k = 1, 2, 3, \ldots, n$; and t can be denoted by day, week, month or year, depending on the research question and research intent.

Hence, Y can be represented by the vector,

$$Y = [\, y_{ij}^1 \quad y_{ij}^2 \quad y_{ij}^3 \quad y_{ij}^4 \cdots \quad y_{ij}^n \,]$$

The ports-of-call of the shipping service determine the regions served by that service. For example, if the vessels of a shipping service call at three ports in China, Japan and West Coast of North America respectively, the slot capacity deployed is deemed to serve all three regions. In other words, the port-of-call in China is connected to Japan and the West Coast of North America; the port-of-call in Japan is connected to the other two regions and so on.

Shipping services connected to the port of Singapore and the port of Hong Kong are numerous and the slot capacity deployed by each service connected to each port is added one by one. Adding all shipping services, the annual slot capacity connected to the two ports for the years 2000–2006 are computed respectively. Particularly, slot capacity data are categorised by the shipping lines and trade routes connected to the two ports. Hence, it is possible to identify the top lines calling the ports and the top trade routes served by the ports. Percentage share of slot capacity of a target (e.g. liner) among the total capacity and percentage change of slot capacity over the previous year are computed for easy reference to the trends.

4. Potentials of slot capacity analysis

This study contributes to the literature by illustrating the potential of slot capacity analysis for industry analysis, market research and academic research. This section explains why it can be a useful tool and the benefits that can be brought to interested parties such as industry practitioners and researchers.

4.1. A tool for analysing patterns of maritime supply chains

Slot capacity data can be used to analyse patterns of maritime supply chains by observing the ports (as nodes) and the routes or lines (as links) that are embedded within the chain. The analyses can be scaled in terms of geographic coverage at the regional, inter-regional and global levels. Industry analysts and researchers would be interested in information on the connectivity of ports and total slot capacity deployed for a certain region or trade route. For example, they can have detailed information on the major ports served and shipping lines plying a trade route (e.g. transpacific), and these can be distinguished by their respective slot capacities. The trade-related information is important for shippers/manufacturers/traders to plan and analyse their supply chains.

4.2. A tool for competitor analysis

Actual container throughput handled by a port differentiated by each shipping line is not made known to the public. The data is considered to be commercially sensitive by both ports and shipping lines. However, slot capacity data is publicly available. It allows an analysis of the networks of target ports (as nodes) and target routes or lines (as links) in the maritime supply chain without the need for accessing sensitive data which is difficult, if not impossible, to collect. In other words, an interested party can use slot capacity data to assess the supply chain platform of a target entity. For example, a shipping line may use it for a detailed assessment of its competitors' supply chain platform because the major ports-of-call and slot capacity deployed by each carrier for each market can be revealed. Similarly, a port can make a slot capacity analysis of other competing ports.

4.3. A tool for customer analysis

Slot capacity analysis can generate useful information on shipping lines which would help ports assess their existing and potential customers, which are the ports' partners in maritime supply chains. This is a proactive approach to better understand them. Specifically, ports would be interested to know the call patterns of shipping lines, for instance, whether a port's customers call increasingly at other competing ports. Another example is for ports to comprehend major trade routes and new trade routes served by the shipping lines.

4.4. A tool for supplier analysis

Ports can do customer analysis by examining slot capacity data. Shipping lines are able to use this tool for analysing existing and potential suppliers (i.e. the ports), which are the liners' partners in maritime supply chains. This is an objective approach to assess them. Information such as network coverage and major liners served by the ports can be obtained.

5. Detailed analyses on selected cases

5.1. Justifications for choosing Singapore and Hong Kong

This study chose the ports of Singapore and Hong Kong for detailed analyses to illustrate the usefulness of slot capacity analysis as a springboard for delving into maritime supply chains.

The two ports have been the world's busiest container ports for more than a decade. They both operate at a large scale in terms of container throughput as can be seen from Table 1. Since 2005, Singapore has taken over Hong Kong as the world's busiest container port which handled almost 30 million TEUs in 2008. It represents a growth rate of 7.3% over 2007. Hong Kong, which handled over 24 million TEUs in 2008, is in the third position of the container port ranking.

Additionally, both ports operate at a large scale in terms of connectivity. The port of Singapore is a focal point for some 200 shipping lines with links to more than 600 ports in over 120 countries worldwide (MPA, 2008). As for Hong Kong, the port is served by some 80 international shipping lines providing over 450 container liner services per week connecting to over 500 destinations worldwide (HKPDC, 2008). This shows that the ports are vital nodes for numerous links with substantial volumes connected to various regions where suppliers and consumers are located. This is why the two ports are commonly referred to as hub ports.

However, whereas Singapore can be considered as a transhipment hub, Hong Kong is considered to be more of a gateway hub as the transhipment incidence of the latter was lower than 40% on average from 2000 to 2006 (HKMD, 2008). While seaward connectivity is vital for transhipment ports, inland intermodality is important for gateway ports. This differentiation also allows us to use both ports as representative cases for analysing maritime supply chains from the transhipment and gateway perspectives.

5.2. Analyses on the shipping lines connected to the ports

5.2.1. Singapore

Table 2 shows the top 10 container shipping lines connected to the port of Singapore in terms of slot capacity deployed for the

Table 1
Top 20 container ports in 2008 (in terms of container throughput in TEUs). Source: Lloyd's List (2009).

Rank	Port	Country	2008 (TEU)	2007 (TEU)	Change (%)
1 (1)	Singapore	Singapore	29.97m	27.93m	+7.3
2 (2)	Shanghai	China	27.98m	26.15m	+7.0
3 (3)	Hong Kong	China	24.25m	24.00m	+1.1
4 (4)	Shenzhen	China	21.40m	21.09m	+1.5
5 (5)	Pusan	South Korea	13.45m	13.26m	+1.4
6 (7)	Dubai	UAE	11.80m	10.65m	+10.8
7 (12)	Guangzhou	China	11.00m	9.26m	+18.8
8 (11)	Ningbo	China	10.80m	9.35m	+15.5
9 (6)	Rotterdam	Netherlands	10.78m	10.79m	−0.1
10 (10)	Qingdao	China	10.32m	9.46m	+9.1
11 (9)	Hamburg[a]	Germany	9.70m	9.90m	−2.0
12 (8)	Kaohsiung	Taiwan	9.68m	10.26m	−5.7
13 (14)	Antwerp	Belgium	8.66m	8.17m	+6.0
14 (17)	Tianj in	China	8.50m	7.10m	+19.7
15 (13)	Los Angeles	US	7.85m	8.36m	−6.0
16 (16)	Port Klang[a]	Malaysia	7.80m	7.12m	+9.6
17 (15)	Long Beach	US	6.49m	7.31m	−11.3
18 (18)	Tanjung Pelepas	Malaysia	5.60m	5.50m	+1.8
19 (20)	Bremerhaven	Germany	5.50m	4.89m	+12.4
20 (19)	New York[a]	US	5.48m	5.30m	+3.3

Rank in brackets refers to 2007.
[a] These are projected figures for the ports of Hamburg, Port Klang and New York.

Table 2
The top 10 lines connected to the port of Singapore in terms of slot capacity deployed (2000–2006). Source: Computed by author.

	Slot capacity (TEU)	% Share	% Change
2006			
MSC	4,242,700	10.65	22.67
Maersk	3,698,200	9.28	−15.11
APL	2,947,400	7.40	11.12
NYK	2,518,570	6.32	11.96
PIL	2,383,200	5.98	10.63
OOCL	2,267,400	5.69	21.13
MOL	2,197,550	5.52	16.14
COSCO	1,956,790	4.91	36.99
Hapag-Lloyd	1,724,500	4.33	10.97
Yangming	1,620,400	4.07	21.99
2005			
Maersk Sealand	4,356,500	11.68	195.42
MSC	3,458,500	9.27	28.35
APL	2,652,400	7.11	11.33
NYK	2,249,600	6.03	3.68
PIL	2,154,200	5.77	6.34
MOL	1,892,150	5.07	17.11
OOCL	1,871,900	5.02	19.24
Hapag-Lloyd	1,554,000	4.17	34.84
Hanjin	1,468,300	3.94	3.39
COSCO	1,428,390	3.83	−6.76
2004			
MSC	2,694,500	7.87	60.27
PONL	2,508,800	7.33	4.24
APL	2,382,500	6.96	29.17
NYK	2,169,700	6.34	21.52
PIL	2,025,700	5.92	6.55
MOL	1,615,700	4.72	6.26
OOCL	1,569,900	4.59	10.99
COSCO	1,531,890	4.48	31.99
Maersk Sealand	1,474,700	4.31	7.90
Hanjin	1,420,200	4.15	−8.70
2003			
PONL	2,406,700	7.77	5.87
PIL	1,901,100	6.14	12.31
APL	1,844,500	5.95	−10.43
NYK	1,785,460	5.76	25.89
MSC	1,681,200	5.43	39.95
Hanjin	1,555,500	5.00	19.06
MOL	1,520,500	4.89	−1.66
Kline	1,460,700	4.69	33.49
OOCL	1,414,500	4.54	6.71
Maersk Sealand	1,366,700	4.39	−2.03
2002			
PONL	2,273,200	7.91	−1.70
APL	2,059,300	7.17	−24.18
PIL	1,692,700	5.89	16.33
MOL	1,546,200	5.38	29.63
NYK	1,418,300	4.94	5.80
Maersk Sealand	1,395,000	4.86	471.25
OOCL	1,325,500	4.61	−6.38
Hanjin	1,306,500	4.55	13.47
COSCO	1,208,590	4.21	8.55
MSC	1,201,300	4.18	127.69
2001			
APL	2,715,900	9.92	5.96
PONL	2,312,500	8.44	20.20
Evergreen	2,125,400	7.76	96.16
PIL	1,455,100	5.31	11.83
OOCL	1,415,800	5.17	6.20
Hyundai	1,348,200	4.92	42.13
NYK	1,340,600	4.90	9.48
MOL	1,192,800	4.36	10.16
Hanjin	1,151,400	4.20	3.40
COSCO	1,113,390	4.07	−39.36
2000			
Maersk Sealand	2,962,200	10.45	–
APL	2,563,200	9.04	–
PONL	1,923,800	6.79	–
COSCO	1,836,190	6.48	–
RCL	1,333,900	4.70	–
OOCL	1,333,100	4.70	–
PIL	1,301,200	4.59	–
NYK	1,224,500	4.32	–
Hanjin	1,113,500	3.93	–
Evergreen	1,083,500	3.82	–

years 2000–2006 computed by Eq. (1) introduced above. Derived from Table 2, Fig. 1 depicts the changes in rankings of the lines across the years.

MSC was the largest container line calling at Singapore with 4.2 million TEUs deployed in 2006. MSC was very active in Singapore in the recent years and this was evidenced by its ranking among the top starting from 2004. The slot capacity deployed grew quickly to register at least over 20% increase per annum. Before 2002, MSC was not even within the top 10. But in 2002, its slot capacity connected to Singapore grew by 127.7% over 2001, and its ranking climbed up thereafter. The importance of MSC to Singapore is also reflected by the fact that PSA Singapore and MSC work closely together in their joint venture running the MSC-PSA dedicated facility.

Maersk was the second line connected to Singapore in 2006 for which 3,698,200 TEUs were deployed. It can be seen that Maersk Sealand (renamed – Maersk Line in 2006) topped the list of shipping lines calling at Singapore with 2,962,200 TEUs deployed in 2000. After relocating its operations hub from Singapore to the neighbouring port of Tanjung Pelepas (PTP), Maersk Sealand disappeared from the top 5 ranking. Its decision to relocate its hub from Singapore to PTP in August 2000 had the immediate effect of diverting about 2.0 million TEUs of container throughput, or about 10% of PSA International's volumes handled in Singapore (Singapore Business Times, 2000). In pursuit of its global strategy of vertical integration into the ports sector, its sister company APM Terminals simultaneously took a 30% stake in PTP (Cullinane et al., 2007).

Nevertheless, the strong connectivity offered by Singapore ensures that Maersk Line continues to tranship a significant share of its container traffic through the port of Singapore (Yap and Lam, 2004). It is supported by empirical evidence that Maersk reclaimed the top position again in 2005 with almost 4.4 million TEUs of slot capacity connected to Singapore. This happened also from the acquisition of P&O Nedlloyd in May 2005 (Lloyd's List, 2005) which allowed the carrier to almost double the slot capacity calling at the port.

We expect that the port of Singapore will continue to be a vital base for Maersk Line. Connectivity of a port as mentioned above is a major reason. Major feeder operators in Southeast Asia such as RCL, Sea Consortium and Samudera continue to call at Singapore instead of PTP. Maersk Line is not able to rely solely on PTP's limited connectivity to offer an extensive global shipping network. Also, the terminal capacity in PTP cannot fully absorb the combined throughput of Maersk Sealand and P&O Nedlloyd in the near future in spite of the expansion plans by PTP. The combined entity will also have to rationalise maritime supply chains that in the past utilised either or both ports to capitalise on the incumbent demand complementarities and economies of service scope related to each port. The situation's complexity is further compounded by the host of shippers, freight forwarders and shipping lines involved in these supply chains.

In 2006, number 3 and number 5 container lines connected to Singapore are the two national carriers APL and PIL respectively. When compared to other shipping lines, their rankings are relatively stable. In fact, their positions remained the same for three

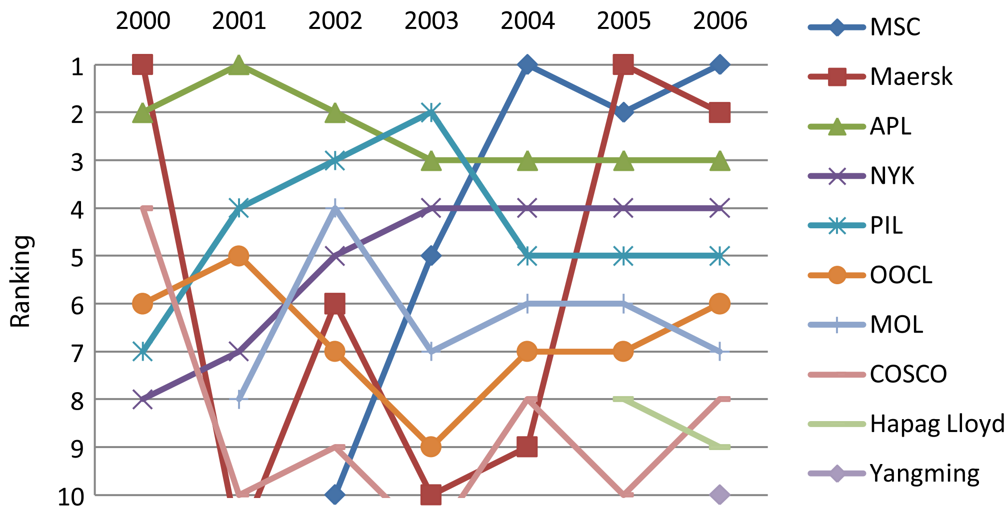

Fig. 1. The top 10 lines connected to the port of Singapore in terms of slot capacity deployed (2000–2006).

years from 2004 to 2006. They play a primary role in Singapore in guaranteeing significant slot capacities calling at the port. This reveals that the "national carriers" of Singapore continue to favour and support their home port in spite of fierce competition from neighbouring ports such as PTP.

Container lines such as NYK, OOCL and MOL had strong presence in Singapore over the years. Some other lines such as Hapag-Lloyd and Yangming have just entered the top 10. As a whole, shipping lines' slot capacity connected to Singapore and their associated rankings fluctuated markedly between the period 2000 and 2006. Especially, we observe that the top 2 lines, MSC and Maersk, differed a lot in their rankings mainly due to the strong influence from port competition and rationalisation of shipping networks.

5.2.2. Hong Kong

Table 3 shows the top 10 container shipping lines connected to the port of Hong Kong in terms of slot capacity deployed for the years 2000–2006 computed. Derived from Table 3, Fig. 2 depicts the changes in rankings of the lines across the years. Maersk Sealand and Evergreen were the two biggest shipping lines which called at the port of Hong Kong. Maersk Sealand topped the rankings in 2006 with 5.7 million TEUs of slot capacity connected to the port which represent a 8.2% decrease from the previous year. Evergreen with 4 million TEUs of slot capacity connected to Hong Kong followed in the second position in 2006.

The Hong Kong carrier OOCL was located in the third place from 2004 to 2006. OOCL remained in the top 10 for seven consecutive years from 2000 to 2006. Similar to the case of Singapore, the "national carrier" plays a primary role in Hong Kong in guaranteeing significant slot capacities calling at the port. This reveals that OOCL continues to favour and support its home port in spite of fierce competition from neighbouring ports such as Shenzhen.

The importance of Hong Kong as a key gateway port that serves the Pearl River Delta saw other major container lines, such as COSCO, MSC and Yangming, devoting a significant amount of slot capacity to call at the port as compared to other ports in the region. As a whole, we observe a strong presence of Chinese and Taiwanese container shipping lines in Hong Kong. In 2006, they were Evergreen, OOCL, COSCO, Yangming and Wan Hai which represented half of the top 10 lines connected to the port. However, the emergence of strong competition from Shenzhen, in terms of pricing and efficiency (Yap and Lam, 2006), could have the effect of encouraging maritime supply chains to bypass Hong Kong.

5.3. Analyses on the trade routes connected to the ports

5.3.1. Singapore

According to Table 4, the predominant trade route served by Singapore is the Europe-Far East trade, which remained in the topmost position for the whole period of study (2000–2006). The route alone accounted for almost one third of all slot capacities that called at the port. In 2006, the route represented a market share of 29.8%. This is followed by the Intra-Southeast Asia (13.5%), Far East–Middle East (13.0%), Mediterranean-Far East (11.3%) and Southeast Asia-Far East (7.1%) trade routes. Notably, the Far East–Middle East trade route became more important to the port of Singapore across the years. It started to become the top 5 trade route connected to Singapore in 2002 and climbed up to a higher position in recent years.

The favourable geographical location of Singapore to serve for these trades resulted in a high transhipment incidence exceeding 80%, making Singapore the largest transhipment port in the world. In other words, Singapore's geographical disposition allows it to serve as a transhipment point for maritime supply chains that traversed among Europe, East Asia, Middle East and Southeast Asia. The supply chain dynamics of the port are largely governed by such market force. These trades' volume and pattern directly affect the performance of Singapore. Hence, Singapore is benefited from and also exposed to supply chains crisscrossing even very remote regions.

5.3.2. Hong Kong

Unlike Singapore, maritime supply chain dynamics of Hong Kong are governed by market forces that shape the gateway business. This is evidenced by the different constitution in terms of trade routes as shown in Table 5 where the spread of market share for Hong Kong was more even, with the Transpacific trade route accounting for 31.0% or 15 million TEUs of total slot capacity that called at the port in 2006. This was followed by the Europe-Far East (25.1%), Southeast Asia-Far East (14.7%), Mediterranean-Far East (10.4%) and Far East–Middle East (7.7%) trade routes. Also, the development of the major trade routes connected to the port of Hong Kong was more stable than Singapore. For Hong Kong, the top 4 trade routes across the years were essentially the same. Furthermore, the trade routes are all connected with the Far East market, reflecting Hong Kong's natural geographical position serving as a gateway to South China. It can be explained by the fact that gateway ports generally serve

Table 3
The top 10 lines connected to the port of Hong Kong in terms of slot capacity deployed (2000–2006). Source: Computed by the author.

	Slot capacity (TEU)	% Share	% Change
2006			
MAERSK	5,698,200	11.78	−8.15
Evergreen	4,044,300	8.36	7.89
OOCL	2,986,400	6.13	−1.04
COSCO	2,690,590	5.56	15.82
MSC	2,532,200	5.24	18.88
Yangming	2,374,600	4.91	19.56
CMA-CGM	2,312,500	4.78	24.21
MOL	2,131,600	4.41	13.14
Wan Hai	2,131,500	4.41	5.31
Kline	2,122,500	4.39	8.02
2005			
Maersk Sealand	6,204,000	12.99	54.74
Evergreen	3,748,700	7.85	8.55
OOCL	3,017,900	6.32	14.04
CSCL	2,702,900	5.66	52.94
COSCO	2,322,990	4.86	3.19
Hanjin	2,230,200	4.67	29.00
MSC	2,130,000	4.46	16.73
APL	2,091,200	4.38	−2.63
Wan Hai	2,024,000	4.24	6.52
Yangming	1,986,100	4.16	−2.90
2004			
Maersk Sealand	4,009,300	9.45	15.15
Evergreen	3,453,300	8.14	-12.21
OOCL	2,646,300	6.24	43.00
COSCO	2,251,190	5.30	20.66
APL	2,147,700	5.06	16.19
Yangming	2,045,500	4.82	6.06
Wan Hai	1,900,200	4.48	-7.74
MSC	1,824,800	4.30	49.06
MOL	1,818,300	4.28	3.63
CSCL	1,767,300	4.16	28.15
2003			
Evergreen	3,933,600	9.77	25.28
Maersk Sealand	3,481,800	8.65	8.48
PONL	2,206,900	5.48	27.68
Wan Hai	2,059,600	5.12	38.95
Hanjin	1,995,000	4.96	9.14
Yangming	1,928,650	4.75	24.87
COSCO	1,865,690	4.60	−6.10
OOCL	1,850,600	4.56	−11.02
APL	1,848,500	4.55	−2.80
MOL	1,754,600	4.32	0.18
2002			
Maersk Sealand	3,209,600	8.64	−4.74
Evergreen	3,139,900	8.45	−4.75
OOCL	2,079,900	5.60	20.39
COSCO	1,986,940	5.35	19.00
APL	1,901,700	5.12	−3.79
Hanjin	1,828,000	4.92	0.08
MOL	1,751,390	4.72	105.35
PONL	1,728,500	4.65	−7.11
Wan Hai	1,573,800	4.24	−10.73
Yangming	1,544,500	4.16	9.09
2001			
Maersk Sealand	3,369,400	9.72	9.56
Evergreen	3,296,600	9.51	2.53
APL	1,976,700	5.70	10.30
Hyundai	1,957,500	5.65	37.42
PONL	1,860,900	5.37	34.56
Hanjin	1,826,500	5.27	−4.51
Wan Hai	1,762,900	5.09	10.53
OOCL	1,727,700	4.98	12.60
COSCO	1,669,640	4.82	−0.97
Kline	1,468,900	4.24	15.89
2000			
Evergreen	3,215,400	10.09	–
Maersk Sealand	3,075,500	9.65	–
Hanjin	1,912,800	6.00	–
APL	1,792,100	5.62	–
COSCO	1,685,940	5.29	–
Wan Hai	1,594,900	5.01	–
OOCL	1,534,400	4.82	–
Hyundai	1,424,500	4.47	–
PONL	1,383,000	4.34	–
Kline	1,267,500	3.98	–

the captive hinterland, but transhipment ports are more vulnerable to foot-loose transhipment business.

As noted, Hong Kong faces very keen competition from neighbouring ports in South China. The effect can be quantified by our analysis on trade routes connected to Hong Kong. Both of the top 2 trade routes, namely Transpacific and Europe-Far East, encountered a decrease in slot capacity deployed calling at Hong Kong in 2006. The percentage change was −7.8% and −6.5% respectively. However, some growing trade routes continued to register higher slot capacity. Particularly, the number five trade route Far East–Middle East saw a prominent growth rate of 33.0% in 2006.

5.3.3. A note on slot capacity and container throughput

We notice that Hong Kong registered higher slot capacity calls, in absolute terms, on the major east–west trade routes vis-à-vis Singapore. Gateway cargoes are counted once for container throughput handled by the port, while transhipment cargoes double up the container throughput as they are handled twice by the port. We thus suggest that slot capacity data can supplement container throughput data to indicate and compare ports' performance since the demand for calling a particular port can be revealed by the slot capacity connected to it. Another type of information given by slot capacity analysis is containership capacity calling at the port. Ship calls generate port due revenue and possibly business on marine services such as bunkering and ship repair and maintenance. Ship calls generate economic multiplier effects not only from cargo handling. Therefore, slot capacity data is broader than container throughput data. While the analysis brings new insights, the downside is that it does not show the actual utilisation of slot by each port. Hence, it is also interesting to see the ratio of slot capacity/total container throughput by the ports. According to Yap (2009), Singapore's ratio was in the range of 3.21–3.52 over 2000–2006 and stood at 3.21 in 2006. More containers were actually handled for those slot capacity deployed at Singapore. Hong Kong's ratio increased from 3.52 to 4.11 over the same period, representing a less favourable development in terminal handling.

6. Research and practical implications

This paper chose the ports of Singapore and Hong Kong for illustrating how slot capacity analysis can be useful for assessing the platforms of maritime supply chains. It uses empirical data on slot capacity deployed by container shipping lines to provide detailed analyses on the major shipping lines and seaborne trade routes connected to the two ports. The two ports are considered as representative cases for analysing maritime supply chains from the transhipment and gateway perspectives.

The cases of Singapore and Hong Kong reveal that geographical location and changes in the constitution of players can have reverberations on maritime supply chain dynamics that traverse the port. Moreover, evidence from shipping lines and trade route data also shows that maritime supply chain dynamics associated with different ports could be governed by different levels of scope economies, demand complementarity and market power.

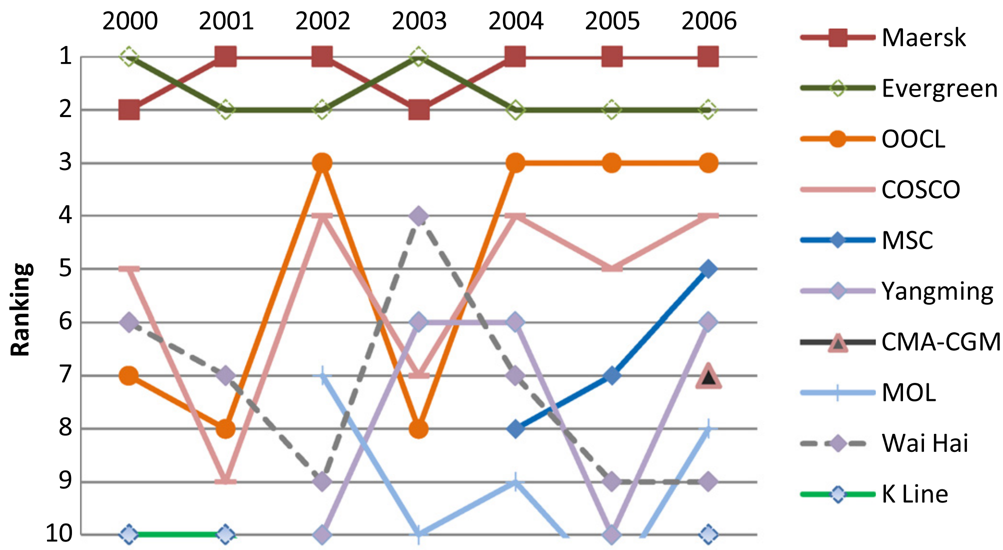

Fig. 2. The top 10 lines connected to the port of Hong Kong in terms of slot capacity deployed (2000–2006).

Table 4
The top 5 trade routes connected to the port of Singapore in terms of slot capacity deployed (2000–2006). Source: Computed by the author.

	Slot capacity (TEU)	% Share	% Change
2006			
Europe-Far East	11,848,230	29.75	1.79
Intra-Southeast Asia	5,374,790	13.49	19.64
Far East–Middle East	5,195,970	13.04	7.82
Mediterranean-Far East	4,516,930	11.34	27.07
Southeast Asia-Far East	2,812,580	7.06	−6.62
2005			
Europe-Far East	11,639,950	31.20	1.16
Far East–Middle East	4,819,200	12.92	36.63
Intra-Southeast Asia	4,492,590	12.04	−0.38
Transpacific	4,056,460	10.87	−5.79
Mediterranean-Far East	3,554,630	9.53	10.18
2004			
Europe-Far East	11,506,550	33.62	14.62
Intra-Southeast Asia	4,509,640	13.18	12.87
Transpacific	4,305,690	12.58	−1.69
Far East–Middle East	3,527,300	10.31	13.16
Mediterranean-Far East	3,226,230	9.43	8.17
2003			
Europe-Far East	10,038,450	32.40	15.41
Transpacific	4,379,590	14.14	−4.70
Intra-Southeast Asia	3,995,350	12.90	−12.06
Southeast Asia-Far East	3,293,380	10.63	11.30
Far East–Middle East	3,117,200	10.06	9.72
2002			
Europe-Far East	8,697,700	30.28	0.02
Transpacific	4,595,600	16.00	4.69
Intra-Southeast Asia	4,543,290	15.82	15.48
Southeast Asia-Far East	2,958,980	10.30	−6.53
Far East–Middle East	2,841,140	9.89	33.02
2001			
Europe-Far East	8,696,100	31.75	−3.51
Transpacific	4,389,640	16.03	−11.20
Intra-Southeast Asia	3,934,430	14.37	−16.14
Southeast Asia-Far East	3,165,640	11.56	16.32
Mediterranean-Far East	2,709,280	9.89	−18.03
2000			
Europe-Far East	9,012,000	31.79	–
Transpacific	4,943,240	17.43	–
Intra-Southeast Asia	4,691,850	16.55	–
Mediterranean-Far East	3,305,250	11.66	–
Southeast Asia-Far East	2,721,460	9.60	–

Table 5
The top 5 trade routes connected to the port of Hong Kong in terms of slot capacity deployed (2000–2006). Source: Computed by the author.

	Slot capacity (TEU)	% Share	% Change
2006			
Transpacific	15,008,190	31.03	−7.84
Europe-Far East	12,119,330	25.06	−6.46
Southeast Asia-Far East	7,096,940	14.68	1.92
Mediterranean-Far East	5,003,900	10.35	10.27
Far East–Middle East	3,727,900	7.71	32.98
2005			
Transpacific	16,285,030	34.10	1.37
Europe-Far East	12,955,750	27.13	13.11
Southeast Asia-Far East	6,962,940	14.58	6.54
Mediterranean-Far East	4,537,700	9.50	13.58
Far East–Middle East	2,803,300	5.87	16.63
2004			
Transpacific	16,065,260	37.85	14.59
Europe-Far East	11,453,650	26.99	−0.29
Southeast Asia-Far East	6,535,240	15.40	−8.48
Mediterranean-Far East	3,995,100	9.41	9.39
Intra-Far East	2,480,040	5.84	−2.94
2003			
Transpacific	14,020,090	34.83	4.70
Europe-Far East	11,486,750	28.54	2.96
Southeast Asia-Far East	7,140,740	17.74	11.42
Mediterranean-Far East	3,652,300	9.07	49.78
Intra-Far East	2,555,180	6.35	11.33
2002			
Transpacific	13,391,100	36.05	3.20
Europe-Far East	11,157,000	30.04	6.74
Southeast Asia-Far East	6,409,050	17.26	19.45
Mediterranean-Far East	2,438,500	6.57	−14.54
Far East–Middle East	2,302,800	6.20	18.23
2001			
Transpacific	12,975,600	37.43	10.24
Europe-Far East	10,452,300	30.15	11.76
Southeast Asia-Far East	5,365,630	15.48	4.57
Mediterranean-Far East	2,853,300	8.23	−7.11
Transatlantic	2,456,000	7.08	1.14
2000			
Transpacific	11,770,600	36.94	–
Europe-Far East	9,352,300	29.35	–
Southeast Asia-Far East	5,131,350	16.10	–
Mediterranean-Far East	3,071,770	9.64	–
Transatlantic	2,428,320	7.62	–

Scope economies enjoyed by port users will be dependent on the variety of regions and trade routes to which a port is connected. Higher seaward connectivity represents higher economies. In turn, these are dependent on the service provision by shipping lines which will vary in terms of service frequency, types of vessels deployed, schedule of port calls and collaborating partners (if any) among other considerations. Collectively, these factors jointly determine the dynamics associated with scope economies that a port can reap. This is particularly important for global shippers/manufacturers/traders who can benefit from a port which is well connected to global supply chains.

As for demand complementarity, ports could have complementarity relationship when they are connected by trade routes and serve the same supply chain (Yap and Lam, 2004). This happens in, for example, a port pair of import and export, and hub-and-spoke ports.

Turning to market power, the degree of power embedded within the market structure of a container port affects the effective working of the market economy. This is determined by factors such as port competition, the number and nature of terminal operators and shipping lines. A competitive structure is more likely to generate equilibrium results that tend towards competitive outcomes whereas a monopolistic structure would yield equilibrium results that gravitate towards monopolistic outcomes.

Transhipment cargoes can enjoy network, scale and scope economies by transhipping at hub ports. Direct call cargoes which go direct from the port of origin to the port of destination rather than facing transhipment at another location can avoid associated implications of higher risks to cargo damage, security concerns and additional handling costs among other considerations. Chopra and Meindl (2007) enunciate that the objective of every supply chain is to maximise the overall value generated. No matter going for transhipment or not, the consideration should focus on optimising the overall value generated by the maritime supply chain, meaning to manage the overall cost and revenue to the best possible way.

On the whole, the study details the usefulness of slot capacity for analysing maritime supply chains. Above all, the capacity deployed by liner shipping services represents the actualisation of supply chain capacity. The characteristics embodied within slot capacity also show that investigation of supply chain dynamics have to encompass the detailed arenas and avenues where such relationships exist. These dynamics, which will not be captured by analyses conducted at the aggregate level, are of great importance to stakeholders and decision makers, such as shippers/manufacturers/traders, liners, port authorities and port/terminal operators, who have to decide on the amount and direction of resources to commit. This draws managerial and policy implications for stakeholders to improve their competitive position vis-à-vis those players in other competing supply chains.

7. Conclusions

The paper introduces a new and versatile technique, slot capacity analysis, for analysing maritime supply chains. It can be a useful tool for various purposes, including both research and practice. As demonstrated by this empirical study, slot capacity analysis is a rigorous approach for purposes such as examining supply chain patterns, competitor analysis, customer analysis and supplier analysis in shipping. In a broader sense, two important groups of information can be revealed: (i) the calling pattern and strategy of shipping lines; (ii) the connectivity and competitive position of ports. Policy makers such as port authorities and port/terminal operators could formulate strategies based on a port's supply chain platform and address issues pertaining to opportunities and threats identified.

More particularly, integration in maritime supply chains can bind the partners in a vertically-collaborative relationship that enables the organisations to accomplish their goals collectively and efficiently. By this, the efficiency and competitiveness of each of the supply chain partners, as well as the supply chain as a whole, would be enhanced.

As for future research, the approach taken by this paper can be undertaken on other container ports. Furthermore, slot capacity analysis offers a lot of potential for research which can be pursued in various contexts and for different applications. Computation and categorisation of slot capacity data in various ways can be used for studying, to name a few, port cluster development, port competition and cooperation, shipping lines' strategies and shipping networks.

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