Inside the pond : an analysis of Northeast Asia's long-term maritime dynamics

César Ducruet

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César DUCRUET
French National Centre for Scientific Research (CNRS)

Abstract

The analysis of historical vessel movements is proposed in this paper to compare recent Northeast Asian port and maritime dynamics with previous development stages back to the late nineteenth century. The changing distribution of vessel calls at and between Northeast Asian ports reveals important shifts of maritime connectivity over time, from the emergence of Japan as the dominant player in the region to a present-day more complex pattern with Hong Kong, Busan, and Shanghai as the major hubs. The analysis also underlines the uneven importance of domestic, intraregional, and extraregional flows as well as the existence of localized, peripheral subnetworks including small and medium-sized ports.

Keywords: historical geography; maritime network; Northeast Asia; port system; vessel movements

1. Introduction

Despite its potential role as a gateway for the Europe-Asia land bridge, Northeast Asia[1] remains, more than ever, a maritime region where sea transport is the principal mean of cargo distribution domestically and internationally. While the region's history is well-known and subject to numerous scholarly works, especially in the field of trade, logistics, and transportation (see Gipouloux, 2011; Rimmer, 2007, 2014), the precise evolution of its port system and maritime network is less (Ducruet, 2015a). Scholars proposing a long-term perspective on port development put much emphasis on one specific port or country, such as China (see a review by Wang and Ducruet, 2013), while region-wide analyses mainly focused on container flows in the recent period only (Ducruet et al., 2010). The network approach combined with a historical perspective can provide new answers to fundamental questions about network growth dynamics in general and port system evolution in particular, as well as novel views about the uneven impacts of technological change and diffusion. Such an approach proved particularly helpful to understand regional integration processes in light of changing maritime connectivity patterns, for instance in North Africa (Mohamed-Chérif and Ducruet, 2014) and Southern Africa (Fraser et al., 2014).

It is the goal of this paper to go back in time and investigate what has been the form and mechanism of transformation of the maritime network in Northeast Asia. One possibility is to verify how much geography and technology have mattered in the centrality shifts among Northeast Asian ports. Centrality in this paper is understood from the perspective of graph theory, or network science, where ports are defined as nodes in a network made of inter-port vessel movements. Thus, port centrality refers to various local, port-level measures such as

[1] In this paper, Northeast Asia is referred to as a region including China, Japan, Taiwan, Far-East Russia, and the Korean Peninsula.

the number of links of each port (i.e. degree centrality) or the number of shortest paths on which each port is situated (i.e. betweenness centrality). Another originality of this paper is to make use of a largely untapped source of information, namely the vessel movement historical database published by Lloyd's List called the *Shipping Index*, to map and analyse maritime flows and networks. One publication was extracted in table format every five years or so between 1890 and 2008, which details the last known inter-port movement of each vessel at the time of the publication around March-April. As the time coverage is very partial, such a source may not fully reflect yearly port dynamics, but rather, provide a rough picture of past trends. Further efforts are being done to extract more systematically this source with the goal of constituting more complete time series of traffic data (Ducruet, 2015b). An originality of the study is that it encompasses the whole fleet of vessels whereas most former works on Asian ports focused on container traffics in the recent period.

The remainders of this paper are organized as follows. The second section examines the results of data extraction from the statistical source and explores the long-term evolution of maritime traffics to highlight main fluctuations. In a third section, we particularly focus on the topological and geographic structure of the network to shed more light on which ports increased their roles in the Northeast Asian maritime network at the expense of others. Lastly we discuss the main results and their implication for current and future Northeast Asian port development.

2. Traffic evolution and distribution

Counting the number of vessel calls for the whole of Northeast Asia is a fruitful exercise to estimate the region's changing importance in world trade (Figure 1). Until the 1950s, total Northeast Asian maritime traffic had increased within reasonable limits, oscillating around 4-5% share of world traffic on average. The trend has been marked by certain shocks such as the sudden increase of 1905, probably caused by trade support to the Russo-Japanese War, the decline due to the First World War (1915) and following the Second World War (1951), the rise of the 1930s and 1940s being explained by the effects of Japan's colonial rule in East Asia and the European presence in China (Gipouloux, 2011).

Subsequently, the share of Northeast Asia in world maritime traffic rapidly increased from 7.7% in 1960 to 17.5% in 2008. Such an evolution can illustrate only partly the overall shift of economic and maritime activity from the Atlantic to the Pacific (Ducruet, 2015b), backed by the independence of formerly colonial countries and the transformation of Hong Kong, Taiwan, and South Korea into newly industrialized countries from the 1960s onwards, with an export-led development strategy. The period 1980-1995 is marked by the effects of China's Open Door Policy following a similar economic model.

[Insert Figure 1 about here]

Another aspect of changing traffic dynamics is obtained by looking at the distribution of vessel calls per country in absolute and relative values (Figure 2). Japan has always been the region's dominant traffic concentration, except in 1890-1895, in 1910, and in 2008 when it ranked second after China. Although Japan's evolution is in line with the Northeast Asian trend, it underwent stabilization and slowdown since the 1980s, compared with the much faster growth of Taiwan, South Korea, China, and Hong Kong. Far East Russia went through wide traffic fluctuations along the period, with also a slowdown since the 1980s but compensated by a recent revival. North Korea, which traffic is recorded since the 1930s only

(at that time being part of a unified yet occupied Korea), experienced rapid growth up to the 1980s and rapid decline since then, as explore more specifically in previous research (Ducruet et al., 2009a), such a trend being caused by combined geopolitical and economic factors.

[Insert Figure 2 about here]

Such evolutions clearly confirm the influence of historical changes on traffic evolution and distribution among Northeast Asian countries. In addition, such countries have been more or less focusing on Northeast Asia itself as the origin or destination of their maritime linkages. Measuring the share of intraregional flows (Figure 3) provides interesting information on the region's importance by country; it corresponds to the share of intraregional vessel movements in the total excluding domestic movements. For most countries, intraregional traffic increased rapidly in the second half of the period, i.e. following the Second World War and alongside new industrial developments. Such a trend may suggest a dynamic of regional integration. As the region's oldest industrial country, Japan had long been the most outward-looking economy through its long-distance connexions with North America, Oceania, and Europe. Due to the technological gaps with world shipping standards, Chinese ports connected principally the world network via Hong Kong in the early days of the 1978 reform, while Hong Kong itself became more and more a hub and gateway for Mainland China (Wang, 1998). From manufacturing centres serving external (global) interests, South Korea and Taiwan became increasingly embedded in regional economic networks (Lee and Rodrigue, 2006), but still with a higher proportion of long-distance linkages in their total maritime activity. Comparatively, North Korea and Far East Russia had become more local since the 1990s already, suffering from the difficult restructuring of their trade networks following the collapse of the Soviet Union.

[Insert Figure 3 about here]

A zoom on China and Japan is provided to better understand their particularities (Figure 4). In both cases, the amount of extraregional maritime flows always surpassed intraregional and domestic flows. Both countries went through drastic decline around 1950 for different reasons: a major political change in China with the proclamation of the People's Republic (1949) and the war effects on Japan's economy in general. Nevertheless, long-distance maritime trade resumed rather rapidly in both cases, but while China continued to grow up to 2008, Japan went through drastic decline since 1990. This latter trend can be explained by the fact that our analysis considers vessel calls instead of vessel tonnage. Fewer vessel calls may hide increasing vessel size and therefore growing trade, especially in a context of growing ship sizes in container shipping. Such a bias was compensated for China due to the continued growth of vessel calls, notwithstanding a drop in 2000 for similar reasons. Another interesting difference between the two countries is the much higher importance of domestic (coastal) shipping for Japan than for China, as it always surpassed intraregional flows.

[Insert Figure 4 about here]

Last but not least, it is possible to measure the respective traffic of sailing and steamer vessels by country and on the level of the whole region compared with world average (Table 1). The share of steamer vessels in total traffic is a good indicator of the successful technological transition in port and shipping operations. As such, Northeast Asia as a whole had always been more advanced than world average, with a 20-30% higher share of steamer vessel traffic all over the period 1890-1925; subsequently sailing vessels became almost non-existent

except in Europe and the West Indies. Japan and Russia had been faster to adopt innovations due to their earlier industrialisation (Japan) and strong focus on heavy industries and shipbuilding (Russia). Analyzing the extent to which steamer traffic has also varied among Northeast Asian ports would go beyond the aim and scope of this study. Therefore, next section concentrates on total traffic to measure network dynamics and port evolutions.

[Insert Table 1 about here]

3. Network structure and port hierarchy

3.1 Overall topology

The Northeast Asian maritime network is made of all inter-port vessel movements for each year under study. The overlap of these movements provided a port-to-port matrix, weighted by the number of movements. Appendix 1 is provided as a benchmark upon which network analysis results can be confronted as it simply represents the port hierarchy based on the number of vessel calls, but without the representation of their linkages.

In terms of network size (Figure 5), the observed evolution confirms the aforementioned traffic evolution based on vessel calls. Yet, the number of links increased faster than the number of nodes (ports) in the network, especially since 1960. This confirms our earlier finding that intraregional flows gained in importance during that second half of the study period. More links imply increased regional connectivity and hence, more probability for regional ports to permit smooth cargo distribution within the area. However, while the concentration ratio of vessel calls among ports did not witness any substantial change over time (*Gini coefficient*), the clustering coefficient went through rapid decline since 1960. This measure is one key indicator of network structure (Ducruet and Lugo, 2012) as it tells us how much nodes' neighbours are also connected to each other. Higher values indicate harmonious or homogenous connectivity among ports, while lower values and especially decreasing values suggest the emergence of a hub-and-spokes structure, i.e. a rather heterogeneous connectivity with few large ports and many small ports, and a centralization of links at hub locations.

Thus, what had appeared as a possible sign of regional integration (i.e. growing intraregional flows) might in fact be explained by growing transhipment and transit trade among neighbouring country ports. Economic development since the 1960s not only created more opportunities for freight distribution, but also it exacerbated competition and specialisation among Northeast Asian ports.

[Insert Figure 5 about here]

3.2 Hub ports and subcomponents

A look at the evolution of inter-port flows reveals interesting trends which were not visible only by looking at the volume of port calls. Table 2 provides the ranking of the top five ports by year, and the discussion is based on the evolving shape of the network and its principal hubs and components that emerge over time, but which were not all visualized for the sake of space (see Figure 6 for a look at four key years between 1960 and 2008). In 1890, Hong Kong and Xiamen are the two main hubs of the region, with the first centralizing Japanese flows and the second mostly Chinese and Taiwanese flows. But these two hubs centralize two

unconnected components. It can be suggested that the fragmented network echoes earlier findings on the dominant core-periphery pattern, which lowers the probability for local, intraregional linkages to exist.

[Insert Table 2 about here]
[Insert Figure 6 about here]

In 1895 however, there is only one tightly connected system with Hong Kong as the main hub followed by Kobe and Shanghai. Transversal linkages occur among Chinese ports (domestic, coastal shipping) but their majority remains at the periphery of the system, as terminal nodes (spokes). In 1900, the pattern is similar but Shanghai became the dominant hub (16 links) before Hong Kong (8) and Kobe (4), with its links equally distributed towards Japanese and Chinese ports. Due to the Russo-Japanese War (1904-1905), Dalian disappeared from the network in 1905, causing high growth at Yantai, another Chinese port situated just across the Bohai Rim in Shandong province. Interestingly, Busan and Incheon emerge in the network but mostly connected to Japanese ports, probably as a reflection of Japan's presence in Korea at the time (naval bases). High growth is also felt at Vladivostok in such context, connected with the main hubs (Shanghai, Hong Kong), as the main connexion port for the Russian Baltic fleet coming for the Battle of Tsushima. Military operations have without any doubt altered commercial routes and ports.

The situation had resumed by 1910, going back to the one in 1900 with Shanghai as the main hub (11 links) followed by Kobe (10), Yokohama (9), Vladivostok (6), and Hong Kong (6). The system remains stable in 1915 with a polycentric structure centred upon Shanghai, Hong Kong, Yokohama, and Vladivostok with comparable degree centrality. These hubs have no particular geographic specialization as they all connect a balanced number of Chinese and Japanese ports. In 1920 however, major hub ports connect each other while being bound to a specific country: Shanghai and China, Hong Kong and Taiwan, South China, Japan, and Yokohama and Kobe with mostly Japan. Vladivostok, a second-order hub port, connected all countries except Hong Kong. To be noted is Incheon, Korea's only port in the network at the time, with only one link to Moji in Japan. Indeed since 1910 officially, Korea belongs to the Japanese Empire and Incheon served as a major gateway port towards Seoul and the rest of the peninsula. No major change affected the network in 1925. In 1930, Yokohama became a much bigger hub with 30 links, followed by Hong Kong (17) and Shanghai (13). This reflects Japan's growth based on industrialisation, trade, and conquest. Interestingly, Busan and Incheon only connect Shanghai. The overwhelming dominance of Yokohama and other Japanese ports continues in 1935, especially given the occupation of parts of China by Japan, until 1945. This dominance is well reflected in the geographic homogeneity of the network where important hubs are fully connected with Japan and do not exhibit anymore specialization on a proximate range. It is still the case in 1940, with the notable difference that Japan is represented by three major hubs (Yokohama, Kobe, Osaka) instead of only one and still dominate Shanghai and Hong Kong, which rank far below. Incheon connects only Shanghai, but Busan connects only Niigata (Japan).

A major change occurred by 1946, after the Second World War, as seen with the reduced centrality of Japanese ports. Yokohama, despite its decline, still occupies a strong position with 12 links, just after Shanghai (14) and even before Hong Kong (11), but it connects mostly smaller ports, while Kobe and Osaka had vanished. The network goes back to previous stages where Shanghai and Hong Kong primarily connected Chinese and Taiwanese ports. In

1951 however, Shanghai's decline illustrates the effects of China's major political change a few years earlier (1949) to such an extent that it connects only Chinese ports in the region as well as Hong Kong, which is the dominant hub (22 links) followed by Yokohama (20) and Kobe (13), while Incheon and Busan connect only Japan. The decline of Japanese ports had been nothing but temporary, as their dominance resumed as early as in 1960. Shanghai and Dalian connect mostly Chinese ports and stand apart of the system, while Incheon and Busan show contrasted behaviour: as the main gateway to Seoul, the first connects the large Japanese hubs while the second only connects secondary East Sea ports such as Nakhodka, Fushiki, Otaru, and Muroran. A subaltern network of peripheral ports emerges, composed of Niigata, Fushiki, Vanino, and Tsuruga, to which are added Chongjin (North Korea), Akita, Vladivostok, and Naoetsu in 1965, still standing apart from the core system centralized by Yokohama, which has maintained its dominance in similar ways than in 1960. It is a rather monocentric network polarized by one highly dominant node (Yokohama) and a few second-order hubs. In 1970, the peripheral subnetwork centred upon Vladivostok and Niigata had gained more importance with the inclusion of 13 ports of which Tokyo, Shimonoseki, and other Japanese ports. This subnetwork became integrated in the main system in 1975, with Nakhodka as the main secondary hub connected to Yokohama, still the dominant node.

A major break occurs in 1980 with an evolution towards a bipolar network structure based on the high centrality of Hong Kong and Yokohama in relatively equal terms. Although Japanese ports continue to dominate the port hierarchy, Hong Kong attracted a wide number of ports under its dominance, mostly Chinese, Taiwanese, Korean, but also Russian, thereby completely transforming the regional pattern. Incheon stands apart with a small subnetwork including only Korean ports (Gunsan, Mokpo, Yosu) and Nagasaki. The high centrality of Yokohama and its secondary hubs (Nagoya, Osaka, and Kobe) is in fact dominantly a domestic shipping system organised around major urban concentrations, with the exception of Nakhodka, a Russian port but centralizing only smaller and relatively peripheral Japanese ports. This trend continues in 1985 as Hong Kong and Yokohama dominate two distinct networks. The one with Hong Kong includes most Chinese ports but a growing number of Japanese ports. A new feature is the role of Shanghai as a subordinate hub of Hong Kong, as well as Kaohsiung (Taiwan) and Tokyo. Incheon still stands apart from the system and includes mainly Korean ports in its small subnetwork (Yosu, Samchok, Ulsan, Gunsan, Donghae) and Naoshima in Japan. The Japanese hubs remain mostly of domestic influence, alongside Nakhodka and a few Chinese ports.

As the Chinese economy grows and Japan stabilizes, the subcomponent of Hong Kong had become even larger than the one of Yokohama by 1990 in terms of the number of included ports. As in the previous years, Busan emerges as a secondary hub and connects Kobe, while Incheon still stands apart in a small subnetwork composed of Ulsan, Gwangyang, Qinhuangdao, and Shimonoseki. The large component of Yokohama now only possesses Kobe, Nagoya, and Osaka as second-order hubs, reflecting upon Japan's shrinking influence in the network. In 1995 this evolution reaches a peak with Hong Kong as the main hub of the whole integrated system. Yokohama now appears as a secondary hub with only Nagoya and Kobe under its direct influence. All other secondary hub primarily connect Hong Kong, such as Tokyo, Nakhodka, Kaohsiung, but also Incheon, Busan, and Shanghai to a lesser extent. Incheon appears more as a local, domestic hub while Busan is more specialized on Japanese and Russian transhipment.

A major change occurred in 2000 with Busan becoming the major hub of the whole system. However, the latter system had split amongst two main components: one with Busan and

Hong Kong as main nodes (with Osaka and Shanghai as secondary hubs) and the second dominantly Japanese with Chiba, Nagoya, Yokohama, and Kobe as central nodes. Nakhodka stands apart at the centre of a Far-East subgroup. In the last year under study (2008), the aforementioned dynamics are prolonged as seen with a huge component centred upon Busan and Hong Kong including several Korean (Onsan, Yosu), Chinese (Shanghai, Tianjin), and Russian (Vladivostok) secondary hubs. Comparatively, a much smaller component including Yokohama, Nagoya, and Chiba lies at the periphery, as well as another small group centred upon Incheon and mostly dominating Chinese Yellow Sea ports.

4. Conclusion

The ambition of this paper was not to question the history of Asia and its ports, but rather, to offer a new perspective on their long-term evolution. This was made possible using a largely untapped data source, the *Lloyd's Shipping Index*, which allowed for the first time to provide a region-wide analysis based on one single measurement unit, the vessel call. Thus, despite the drawbacks of such an approach (e.g. missing information on more local traffics such as junk vessels, unrecorded ship movements, calls instead of vessel tonnage capacity, etc.), Northeast Asian countries and ports could have been compared in a relatively objective manner in terms of their ability to absorb a number of political, economic, and technological changes and transitions in the last 120 years.

Main results are satisfactory is a sense that they convey a general snapshot of the Northeast Asian port system at regular points in time since 1890, without too much discrepancy compared with existing knowledge. The major traffic concentrations and hubs could have been well identified as well as their geographic specialization and the precise turning points where port hierarchies have shifted within the region. While traffic concentration in general has been somewhat stable over the period, we observed a growing centralization of inter-port links. This occurred at the advantage of Japanese hub ports, which superseded China and Hong Kong as the region's pivotal hub. In the 1990s, Hong Kong and South Korea became the leading hubs as part of a more polycentric system, relegating Japan at the periphery. As compared with previous research using similar methods, what became clear is the prominence of transhipment hub ports, such as Busan, backed by ambitious port policies and investment. This major shift toward Busan port could both confirm the spatial characteristics of modern transhipment hubs (Fleming and Hayuth, 1994), such as the route and service optimality required by increasingly global transport actors, and local dynamics stemming from the Kobe earthquake in 1995. In particular, these results could confirm the more recent emergence of South Korea as the leading maritime hub in Northeast Asia, based on the sole analysis of liner shipping networks (Ducruet et al., 2009b), notwithstanding more local dynamics such as the growing importance of local/regional hub ports like Incheon but also Onsan and Yeosu.

Many aspects motivate further research in such directions. For instance, the likely reinforcement of the Arctic Sea Route may in the coming years or so modify profoundly the current trends. As Northeast Asia is not a closed system, the study should be extended to East Asia or the Asia-Pacific to grasp port dynamics in a more comprehensive way, without naming the possibility to analyse in detail how Northeast Asian ports have evolved at the global scale in the world maritime network. A better understanding of past and current port dynamics at multiple scales shall provide novel views on the way future trends can be defined and anticipated. This would necessitate to expand the time coverage of the current study to include the post-2008 period.

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	1890	1895	1900	1905	1910	1915	1920	1925
China	56.2	67.6	77.8	88.4	99.3	99.2	98.9	99.4
Hong Kong	48.6	61.9	70.6	88.9	95.4	98.7	100.0	100.0
Japan	58.2	78.5	74.7	95.5	97.4	97.9	98.6	100.0
South Korea	-	-	-	100.0	100.0	-	-	-
North Korea	-	-	-	100.0	-	-	-	-
Russia	70.0	82.4	90.5	97.6	98.3	100.0	96.0	100.0
Taiwan	10.0	33.3	-	100.0	85.7	100.0	100.0	100.0
Northeast Asia	53.9	70.7	75.5	92.2	97.9	98.7	98.9	99.8
World	36.6	45.6	59.3	71.2	82.1	87.3	88.9	97.2

Table 1: Share (%) of steamer vessels in total maritime traffic, 1890-1925
Source: own elaboration based on Lloyd's Shipping Index

Year	Port centrality ranking					
	1	2	3	4	5	6
1890	Hong Kong	Xiamen	Kobe	Fuzhou	Tainan	-
1895	Hong Kong	Shanghai	Yokohama	Kobe	Nagasaki	Shimonoseki
1900	Shanghai	Hong Kong	Yokohama	Nagasaki	Moji	Kobe
1905	Kobe	Hong Kong	Shanghai	Yokohama	Nagasaki	Shantou
1910	Shanghai	Kobe	Yokohama	Vladivostok	Moji	Hong Kong
1915	Hong Kong	Yokohama	Shanghai	Vladivostok	Kobe	Nagasaki
1920	Hong Kong	Yokohama	Shanghai	Kobe	Vladivostok	Qinhuangdao
1925	Yokohama	Shanghai	Hong Kong	Kobe	Dalian	Vladivostok
1930	Yokohama	Hong Kong	Shanghai	Dalian	Kobe	Keelung
1935	Yokohama	Hong Kong	Shanghai	Dalian	Kobe	Vladivostok
1940	Yokohama	Kobe	Hong Kong	Shanghai	Osaka	Dalian
1946	Shanghai	Yokohama	Hong Kong	Yokosuka	Qingdao	Qinhuangdao
1951	Hong Kong	Yokohama	Kobe	Osaka	Shanghai	Fuzhou
1960	Yokohama	Hong Kong	Kobe	Osaka	Moji	Nagoya
1965	Yokohama	Moji	Osaka	Hong Kong	Kobe	Yawata
1970	Yokohama	Hong Kong	Kobe	Vladivostok	Osaka	Nagoya
1975	Yokohama	Kobe	Osaka	Nakhodka	Nagoya	Chiba
1980	Yokohama	Hong Kong	Osaka	Kobe	Nagoya	Chiba
1985	Yokohama	Kobe	Hong Kong	Nagoya	Chiba	Osaka
1990	Hong Kong	Yokohama	Nagoya	Kobe	Osaka	Chiba
1995	Hong Kong	Yokohama	Tokyo	Busan	Ulsan	Nagoya
2000	Busan	Hong Kong	Nagoya	Kobe	Ulsan	Chiba
2008	Busan	Hong Kong	Shanghai	Nagoya	Onsan	Tianjin

Table 2: Network centrality ranking of Northeast Asian ports, 1890-2008
Source: own elaboration based on Lloyd's Shipping Index

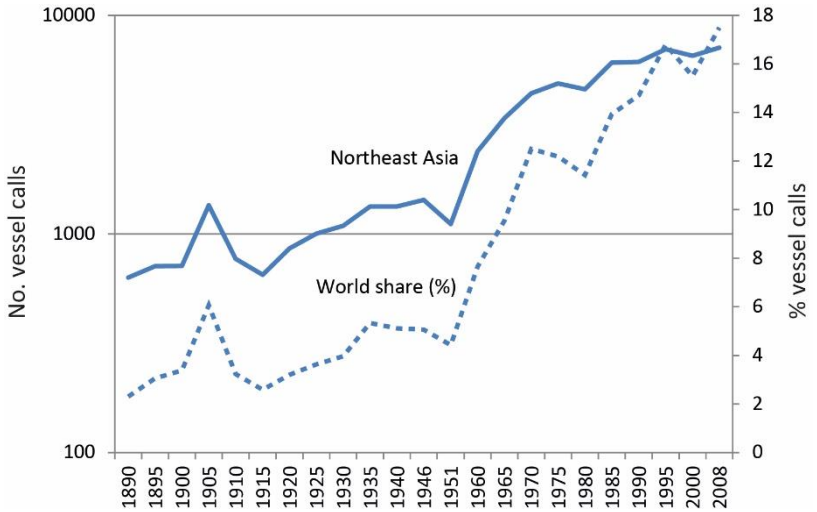


Figure 1: Maritime traffic of Northeast Asia, 1890-2008
Source: own elaboration based on Lloyd's Shipping Index

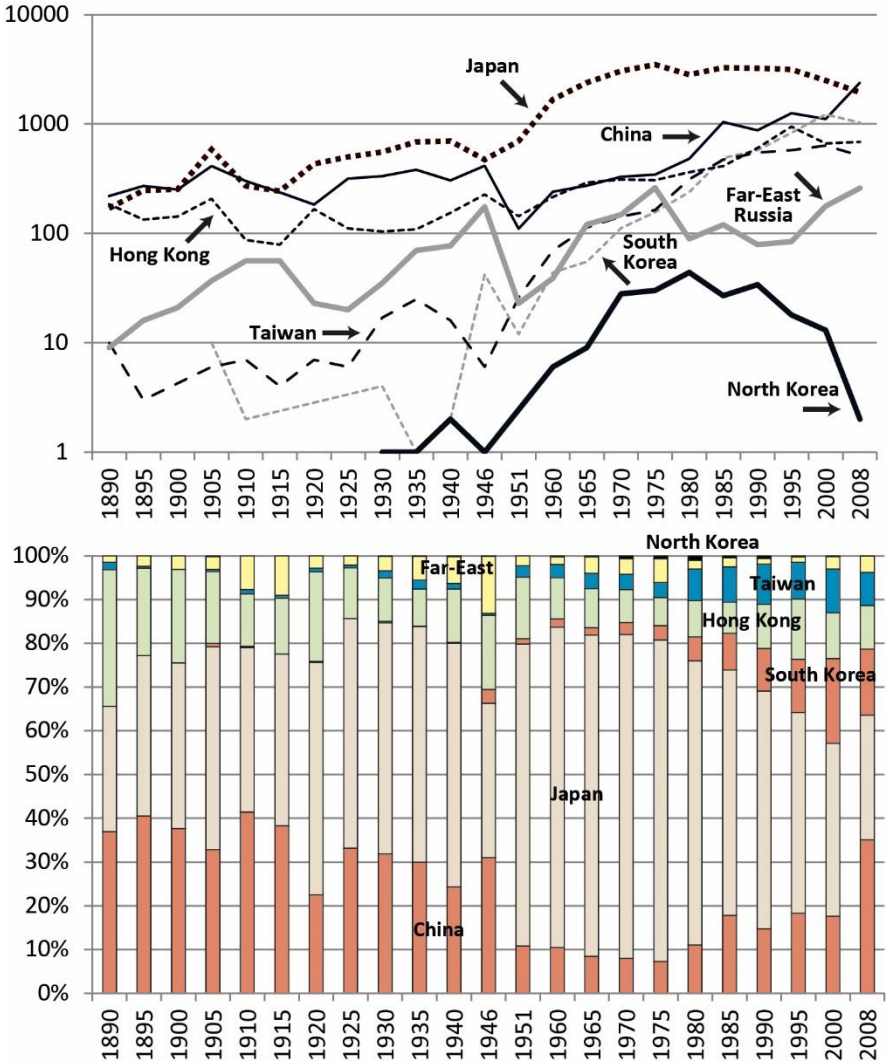


Figure 2: Evolution of maritime traffic by Northeast Asian country, 1890-2008
Source: own elaboration based on Lloyd's Shipping Index

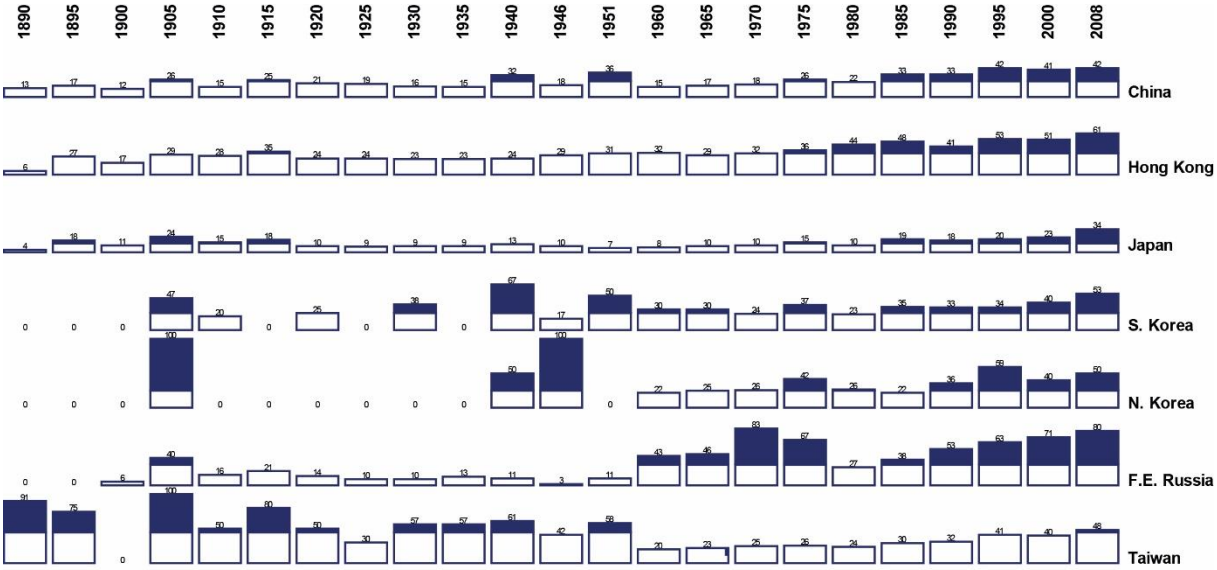


Figure 3: Share of intraregional traffic by Northeast Asian country, 1890-2008
Source: own elaboration based on Lloyd's Shipping Index
N.B. the size expresses the share of interregional traffic (%) in total traffic, and the dark blue colour applies to values over the country's average over the period

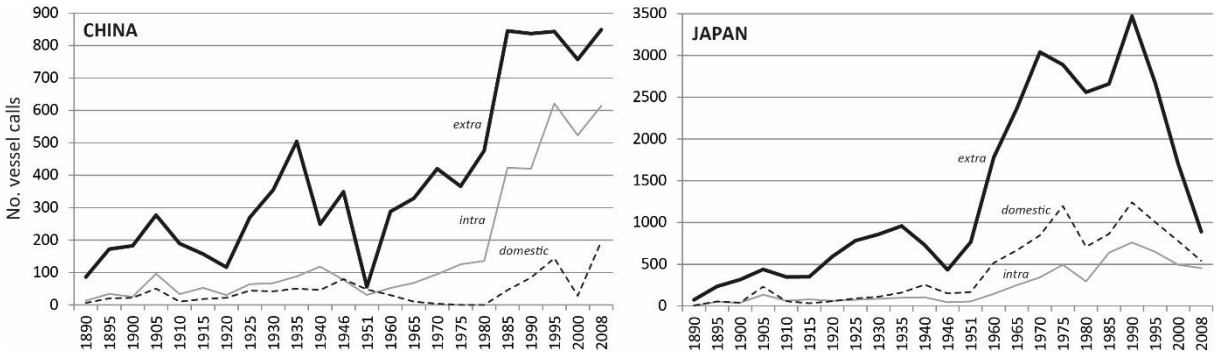


Figure 4: Contrasted evolutions: China and Japan, 1890-2008
Source: own elaboration based on Lloyd's Shipping Index

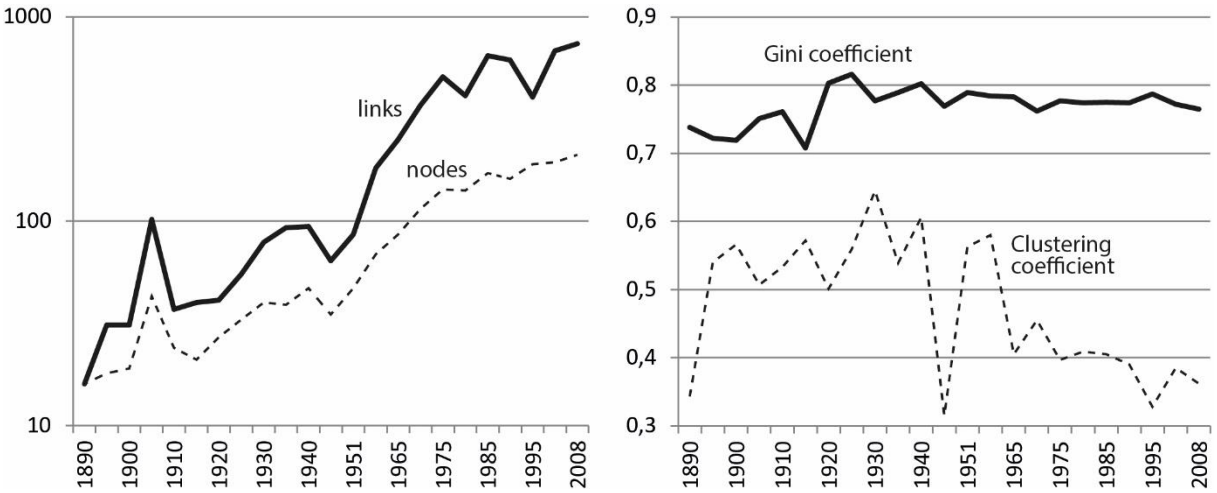


Figure 5: Network size and connectivity, 1890-2008
Source: own elaboration based on Lloyd's Shipping Index

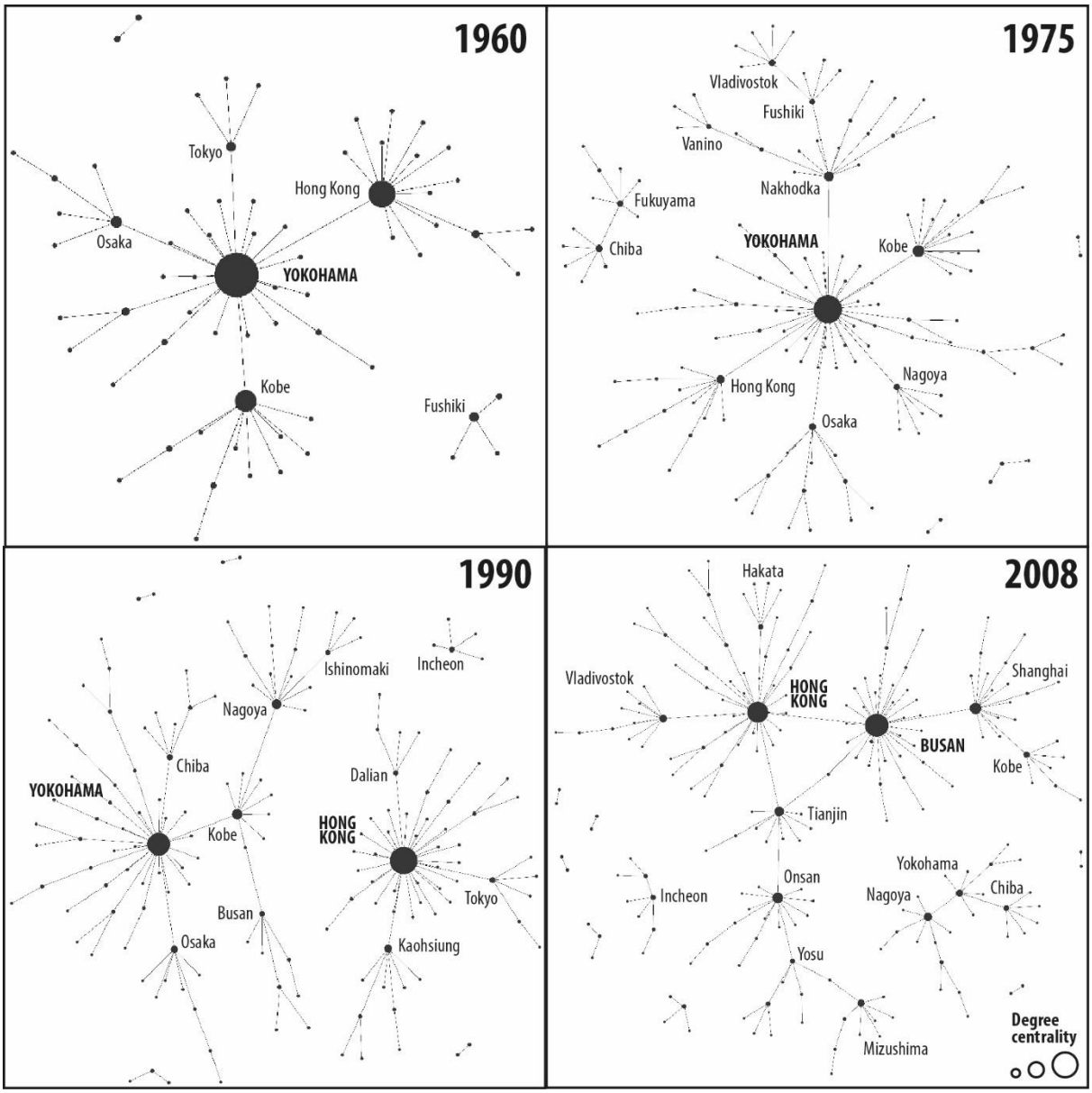
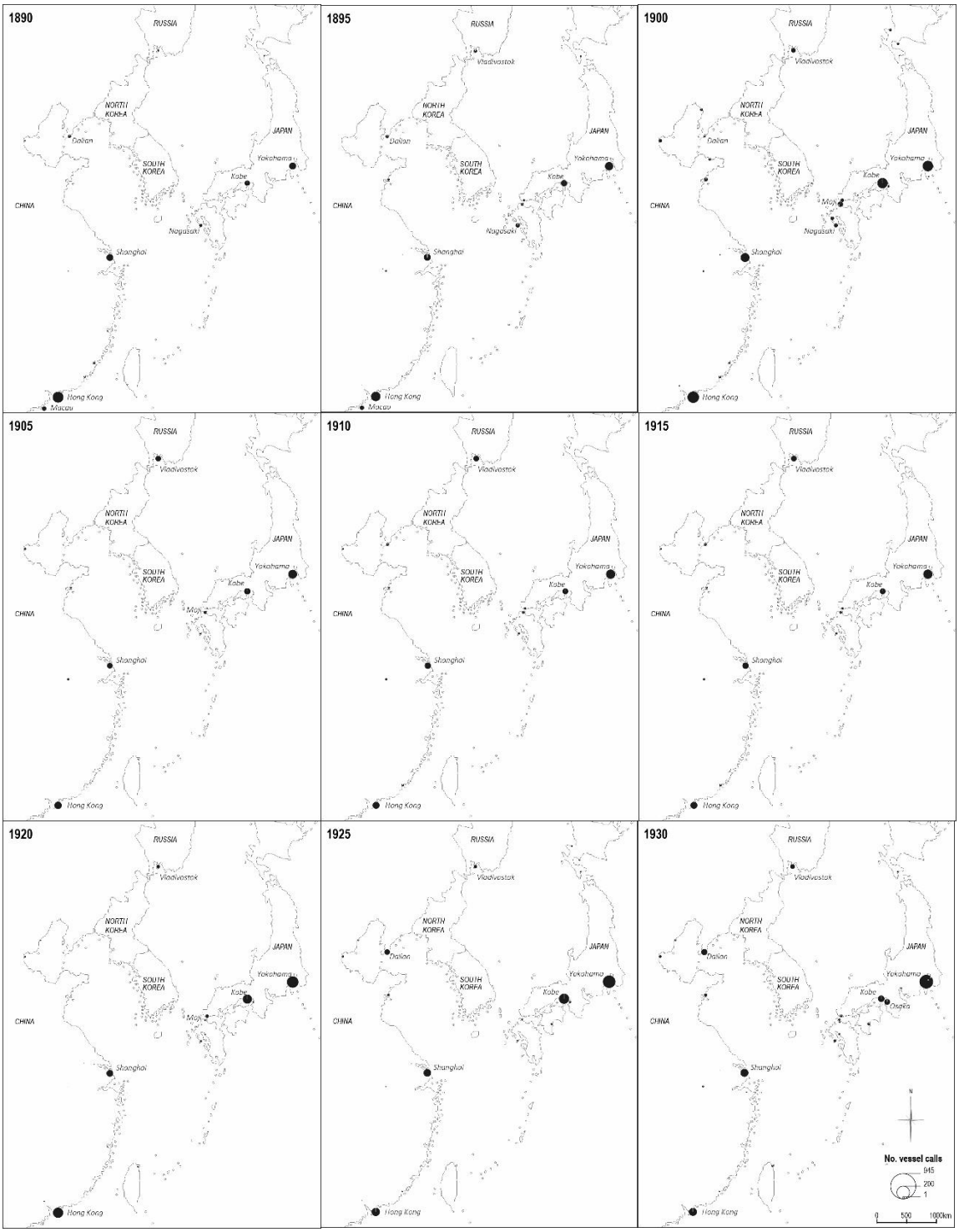
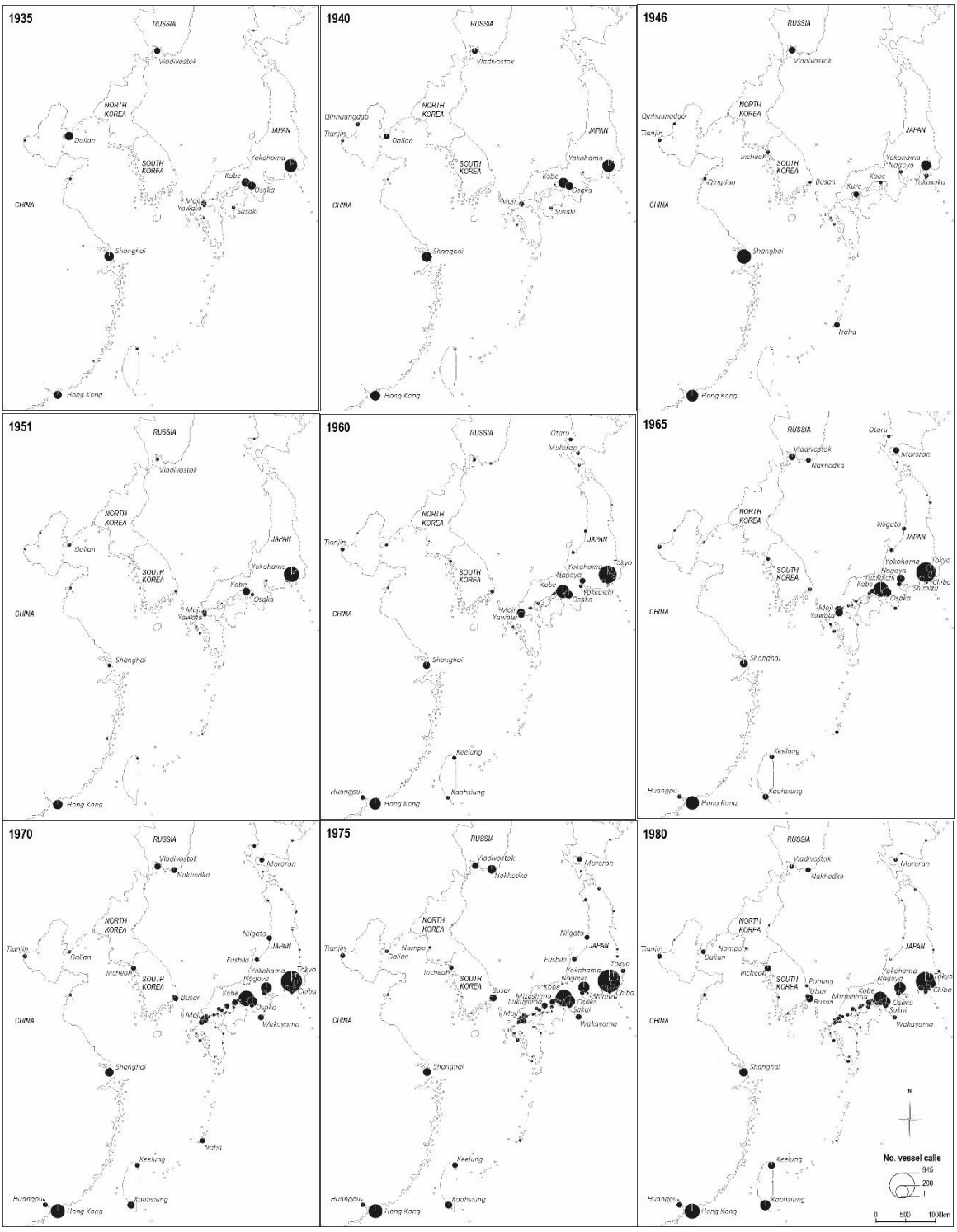


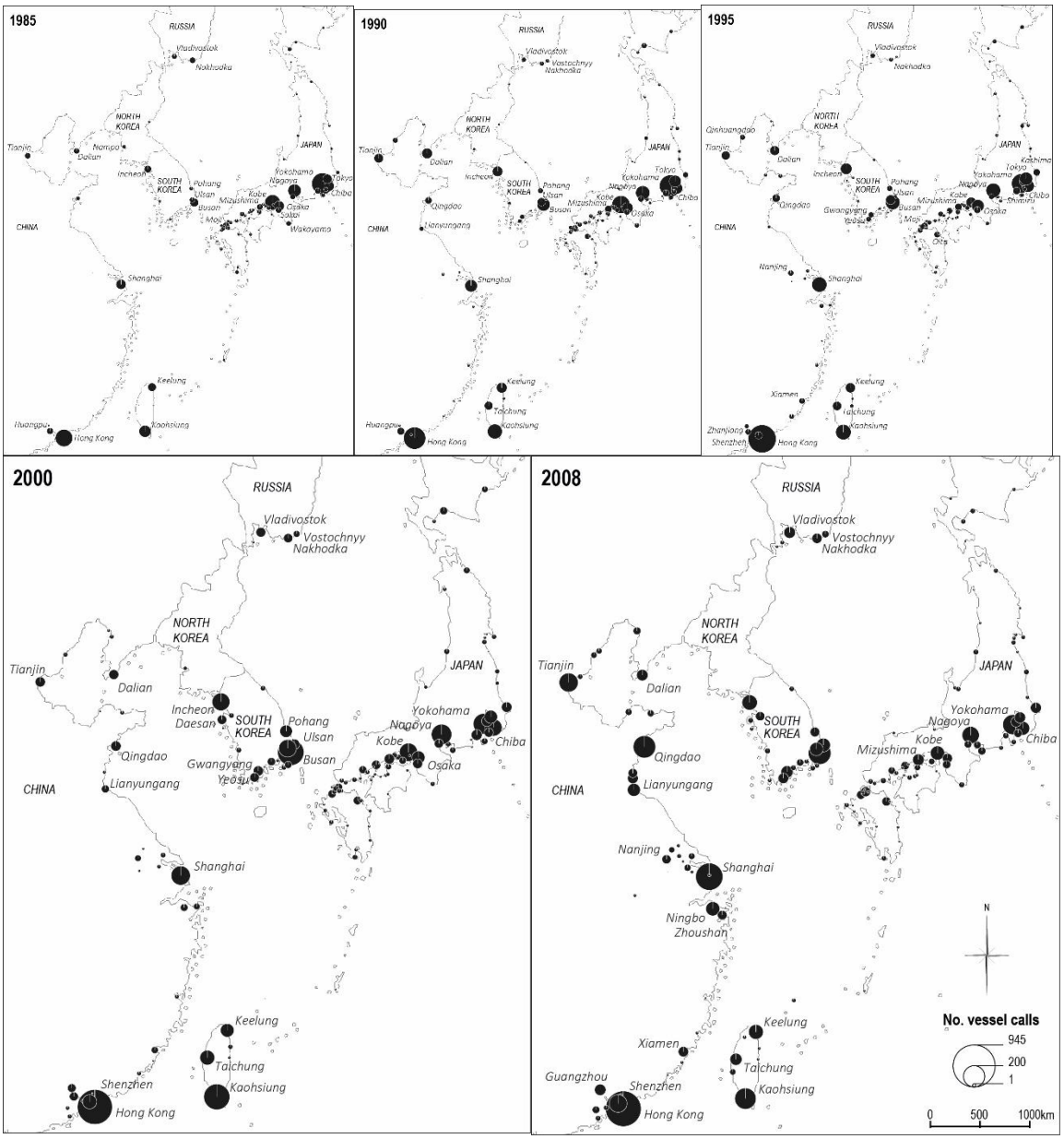
Figure 6: Hubs and subcomponents in the Northeast Asian maritime network, 1960-2008
Source: own elaboration based on Lloyd's Shipping Index



Appendix 1a: Northeast Asian port hierarchy, 1890-1930
Source: own elaboration based on Lloyd's Shipping Index



Appendix 1b: Northeast Asian port hierarchy, 1935-1980
Source: own elaboration based on Lloyd's Shipping Index



Appendix 1c: Northeast Asian port hierarchy, 1985-2008
Source: own elaboration based on Lloyd's Shipping Index