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China's container-related dynamics, 1990–2005

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Abstract This study seeks to gauge how far China's container-related dynamics between 1990 and 2005 fit into the wider perspective about transport and development within developing countries. In particular, attention is focussed on the role of specific modes to determine the extent of the penetration of containers within China. Before addressing these key issues extant models relating to an understanding of port and transport evolution in less-developed countries are recalled, synthesized and used as a base upon which an appropriate review of China's case can be conducted. Applying them to China's northern, central and southern port ranges not only helps assess the efficacy of these models but also highlights the contribution of individual modes.

Keywords Anyport · China · Containerization · Port patterns

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Introduction

China's throughput of containers, including Hong Kong, has increased from 6.2 million TEUs in 1990 to over 88.5 million TEUs in 2005, accounting for over 23% of the world total (CIY 1992, 2007). Paralleling this rise of China from third to first rank of world container port traffic by country has been the propulsion of nine of the country's container ports into the top 50 of the world container port league in 2005 compared with only Hong Kong and Shanghai fifteen years earlier. More strikingly, Shanghai, and possibly Shenzhen, is threatening to catch Hong Kong and then topple Singapore from the leading position in the immediate future. China is also the world's foremost manufacturer of ISO (International Organization for Standardization) containers with a market share in 2005 exceeding 93%. Within China these ISO boxes have superseded the small-sized, non-standard containers used primarily by the domestic railways, which have been progressively phased out. These developments have attracted the attention of a host of transport and logistics specialists seeking to track and interpret them.

Historically, Yap and Lam (2006) argue that since 1980 Hong Kong and Busan have been the main beneficiaries of inter-port competition involving container movements in China (Fig. 1). At one stage Hong Kong served China south of the Yangtze and Busan in Korea usurped the position of Japanese ports by offering better cost-quality combinations to

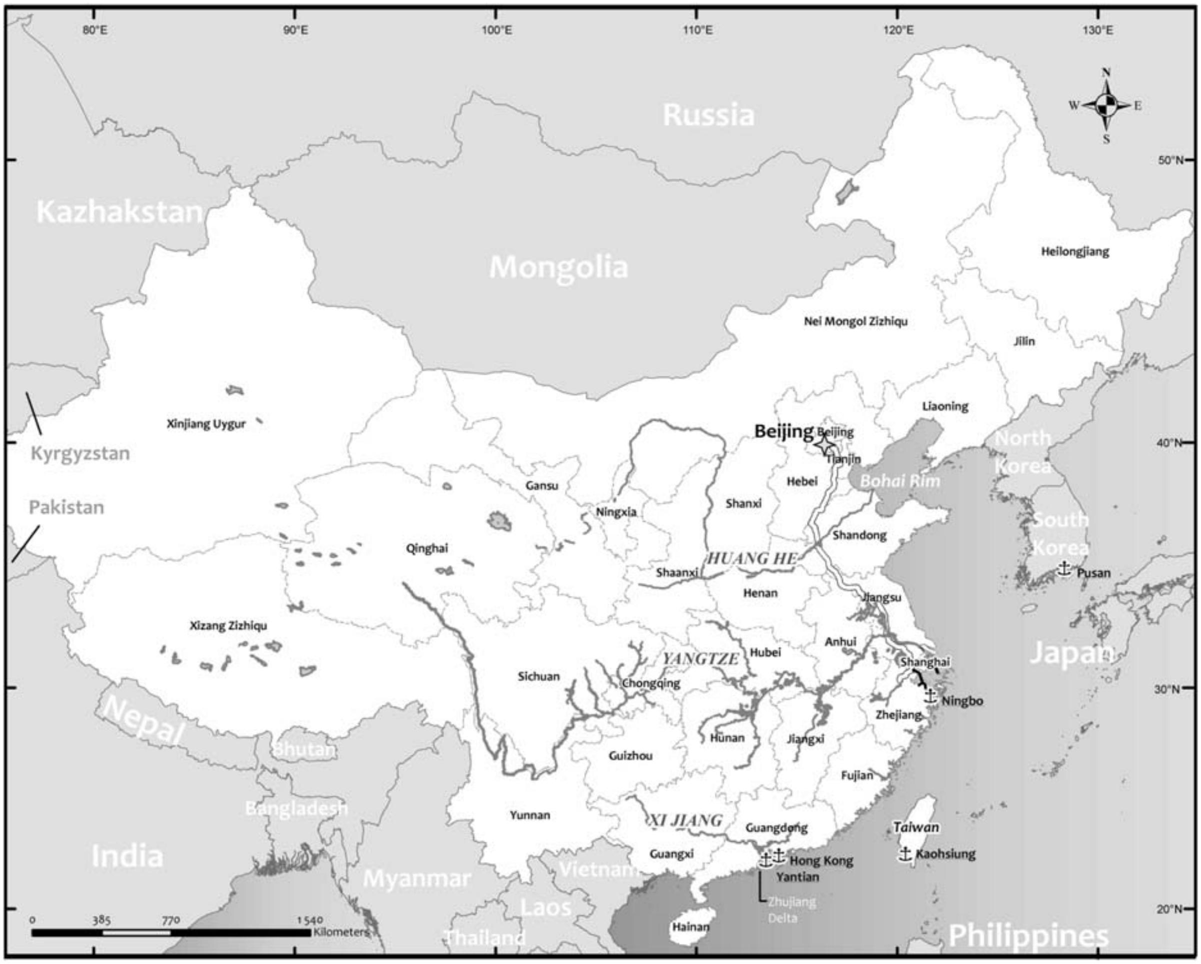


Fig. 1 Location map of China

serve northern China and even some parts of Japan. This pattern is changing with the integration of China's deep-sea ports into global production chains, resulting in a shift away from 'offshore' ports such as Busan and Kaohsiung in Taiwan (Lee and Rodrigue 2006; OECD 2005, pp. 41–45).

Increasingly, attention on containerization within China is being focussed on particular regions, notably the Bohai Rim (Lee and Rodrigue 2006); Shanghai and a string of feeder ports along the Yangtze River, featuring competition between Shanghai and Ningbo (Comtois and Dong 2007; Notteboom 2007; Wang and Olivier 2007); and the Zhujiang [Pearl River] Delta, particularly Hong Kong's changing role (Cheung et al. 2003; Comtois and Slack 2000; Cullinane et al. 2005; Loo and Hook 2002; Wang and Slack 2000). Further, the three competitive ports of Hong Kong and Yantian in the Pearl River Delta and Shanghai in the Lower Yangtze have been compared as they are ranked ahead of Bohai Rim ports (Song and Yeo 2004).

There are also sharp differences of opinion as to the state of container penetration in China. Loo and Hook (2002, p. 219) highlight in their abstract "the high spatial agglomeration of container traffic, the emergence of inland load centres and the growing importance of the railways, the levels and the spatial dimensions of containerization in the People's Republic of China". Conversely, Song (2002) suggests that the country still lacks the panoply of corridors, inland terminals and other necessary infrastructure, despite the major terminal operators having staked out the ports to attract direct calls from major shipping lines.

As yet, there have been few comparative studies that range across the entire set of ports in China to assess the degree and extent to which containers have penetrated hinterlands by inland waterway, rail and road transport. This obvious gap in the literature prompts us to focus on the domestic aspects of China's sea-land development in raising two key issues. How far does China's container-related dynamics fit into the wider perspective about transport and development within developing countries? More specifically, how has the role of particular modes differed in the penetration of containers within China?

In addressing these key issues extant models relating to an understanding of port and transport evolution in lesser-developed countries are recalled, synthesized and then used as a base upon which an appropriate review of China's case can be conducted. Information on container port throughput in 20-foot equivalent units (TEUs) is readily available from the *Containerisation International Yearbook* (CIY 1990–2008); this list is augmented by data from China's Ministry of Communications for seaports located on the Yangtze River. Provincial data on container movements by road and water transport are drawn from *Zhongguo Jiaotong Nianjian* [Yearbook of China Transportation and Communications], but the railway data are misleading and are not analysed further (ZJN 1986–2007). Although the data on road and water transport are not location specific they are sufficient to indicate the changing extent of container penetration by these modes in China.

As the data on international standard 20 and 40 ft containers in *Zhongguo Jiaotong Nianjian* were only made available for the first time in 1988, this prompted us to choose 1990 as the starting point for our analysis (i.e. 12 years after the adoption of China's open door policy in 1978). As there is a time lag in publication, the analysis terminates in 2005. Nevertheless, this period between 1990 and 2005 coincides with a marked upsurge in container throughput in China associated with domestic market reforms and increased participation in world trade and the international division of labour marked by a surge in foreign direct investment and a growth in exports.

As there was continuous growth throughout this period, even during the Asian Crisis of 1997–1998, it is an acceptable strategy to compare the situation in 1990 with that in 2005 without interpolating additional dates. Before taking up the China case itself there is a need to put it into the wider perspective about transport and development by revisiting the model of universal port patterns.

Revisiting universal port patterns

In the 1960s port geographers had the opportunity of pursuing James Bird's (1963, 1967, 1971) 'Anyport' model or changes in inter-port dynamics through the further elaboration of Taaffe et al. (1963) model of transport development in underdeveloped countries. While Bird's Anyport model attracted its devotees (Hoyle 1967, 1974, 1989; Hoyle and Knowles 1992; McCalla 2004), others have preferred to follow the Taaffe, Morrill and Gould model focussed upon the evolution of spatial patterns of port locations with the improvement of internal accessibility and the accompanying process of dominance ranking (Rimmer 2007).

Coloured by its West Africa experience, the Taaffe, Morrill and Gould study, however, did not pursue the development of seaports to its logical conclusion, as this topic was only of secondary importance to the expansion of the land transport network in underdeveloped countries as such. Indeed, in their preoccupation with the development of land communications and the emergence of high-priority 'Main Street', the authors neglected the subsequent development of maritime space.

In an attempt to incorporate changes in both the maritime *and* land transport networks Peter Rimmer (1965) developed a simple descriptive model to serve as a yardstick for comparing the evolution of seaports. This original model was fashioned to account for the development of inter-port competition among New Zealand seaports between 1853 and 1960 (Fig. 2). Over that period the processes of penetration and hinterland capture, interconnection and concentration, and centralization transformed the original pattern of scattered ports along the coastline (Rimmer 1967a). A deconcentration phase (misleadingly referred to initially as decentralization) was added when the model was applied to spatial regularities in the evolution of Australian ports to accommodate the initial generation of purpose-built container ships requiring deeper water and dedicated facilities, typified by the development of Sydney's Port Botany (Rimmer 1967b).

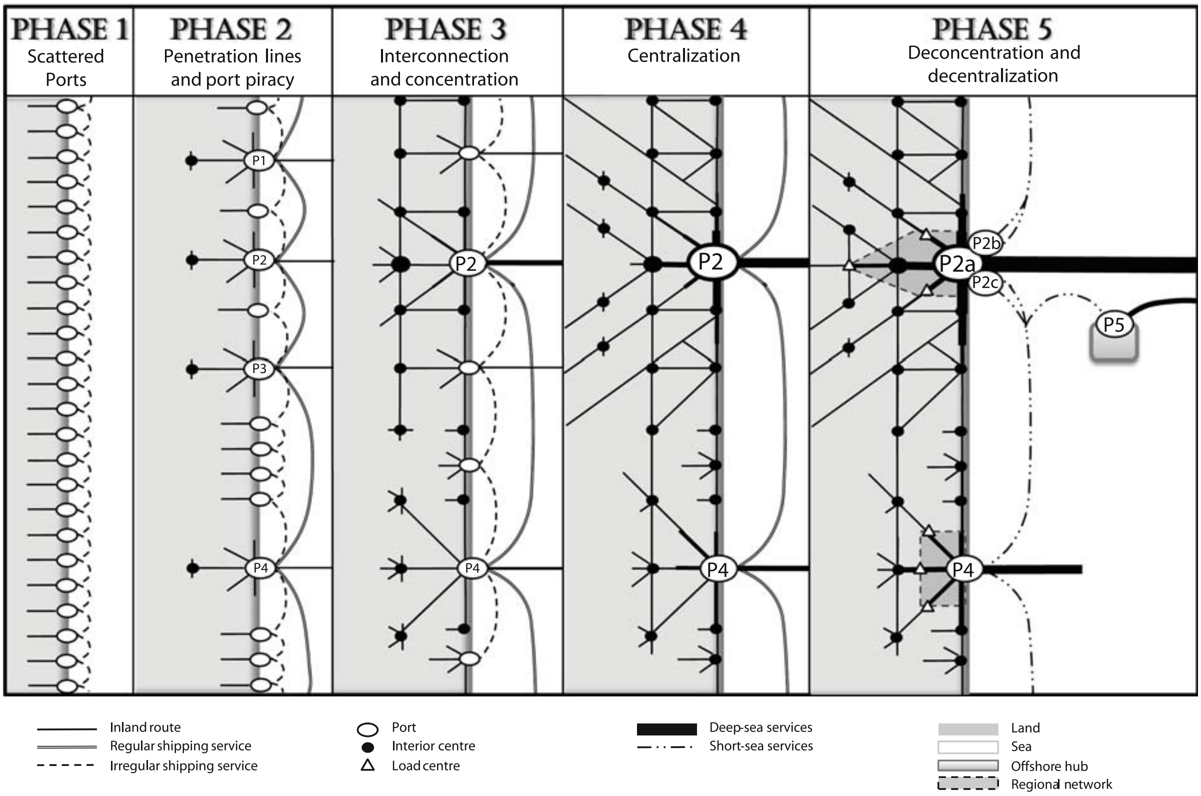


Fig. 2 Port model (*Source*: Rimmer 2007)

Remarkably, these wide-ranging changes, accompanied by growth in the size of container ships and the increasing complexity of global, modular production-distribution chains, required little modification to the original model. The adoption and spread of container technology initially reinforced the concentration phase and then accommodated purpose-built container ports terminals in the deconcentration and decentralization phase of the idealized sequence of port development (Hayuth 1988).

Subsequently, interest in the model subsided until Notteboom and Rodrique (2005) sought to resuscitate it. Less well versed in the model's antecedents, they sought to add an offshore transhipment hub to the fifth phase and suggested an additional sixth phase dubbed 'regionalization'. The addition of the offshore hub was prompted by no less than 17 transhipment centres that appeared by the end of the new millennium offering depths of at least 15 m, room for expansion, lower labour costs, substantially carrier-owned terminals to handle transhipments, and scope for the subsequent development of logistics zones (SET 2002). Typified by Gioia Tauro, this new phenomenon can easily be accommodated by minor surgery to the fifth phase of the model.

Also there is no need for Notteboom and Rodrigue's additional sixth phase because what is regionalization but decentralization? As demonstrated, their additional elements—insertion of load centres, shading discrete regional load centre networks, and the elaboration of coastal feeder networks—can all be accommodated in the fifth phase of the model (Fig. 2). Other than to identify an axial corridor and discontinuous hinterlands, there has been surprisingly little elaboration of the inherited transportation links to reflect the further development of intermodal networks. Indeed, there is a danger that if we become concerned again with inland regionalization per se we will have come full circle by returning to Taaffe, Morrill and Gould's preoccupation with the land-based network, which prompted the development of a model that accommodated the fuller development of maritime space in the first place.

The suggested additions of articulation points, freight corridors and load centres by Notteboom and Rodrigue stem from Robinson's (2002) seminal paper documenting the progressive collapse of separate maritime and land-based firms and functions into an integrated intermodal network providing economies of scale. Also these additions reflect specific logistics developments in Europe, North America and arguably, though not verified, the Asian-Pacific Rim. These attributes have come to the fore in Europe where there is intensified competition within and between north European and Mediterranean port undertakings—operators and port authorities—seeking to generate added value in supply chains (ESPO 2004–2005; Notteboom 2005). In North America similar attributes are evident in the distribution network developed beyond the jurisdictional territory of the Port of New York/New Jersey; the Alameda freight corridor connecting the San Pedro Ports of Los Angeles and Long Beach; and in the Freight Action Strategy for Seattle-Tacoma (FAST) Corridor Partnership within the Puget Sound region (Rodrigue 2004; Rodrigue and Hesse 2007).

In Asia land-based decentralization of containers has been limited by the heavy reliance on feeder shipping centred upon the key hubs of Singapore, Hong Kong, Kaohsiung, Busan and Kobe (Rimmer 1997b, 1998; Robinson 1998). Indeed, there has been a retreat from inland transport networks serving the agricultural interior in Southeast Asia to the mega-urban manufacturing centres on or near the coast (Dick and Rimmer 2003). This has prompted Lee et al. (2008) to see Asia as a deviation from the universal model because of its less well-developed land connections; this only underlines the importance of maintaining the model's emphasis on giving equal importance to the organization of maritime space. Conflating port patterns with the contentious 'port-city' category, however, muddies their well-referenced contribution. The rest of China is forgotten in their preoccupation with excluding the 'local' in typecasting Hong Kong along with Singapore as a 'global hub port city'. Yet China is the only likely area of East Asia where the expression of decentralization is likely to occur on an American or European scale.

China

With this wider perspective about transport and development we are now in a position to discuss China's ISO container-related dynamics between 1990 and 2005. More specifically, we can focus on the growing role of ports in the logistics chain that has prompted heavy investment by China's government since 1995 in maritime and land-based transport infrastructure to handle the explosive growth in container throughput over the period under review. In particular, new seaports have been added to the total complement of container ports. These changes in container port patterns are revealed in a shift-share analysis between 1990 and 2005 (Fig. 3). Apart from a minor loss recorded by Nanjing, the resultant pattern highlights the dispersion of traffic from Hong Kong to all parts of China: the main positive showings being recorded by Shenzhen followed by Shanghai, Qingdao, Guangzhou, Xiamen and Zhongshan. However, this national configuration does not provide a satisfactory basis for analysing port patterns.

The overall pattern of container ports is difficult to relate to the railways. Between 1990 and 2005 China's railway system was upgraded and extended from 53,400 km in 1990 to 62,400 km in 2005—a key feature being the emergence of a north-south 'coastal' rail corridor linking Harbin in Heilongjiang province in the north and Guangzhou on Guangdong province (Fig. 4). Upgrading single-line tracks and electrification was concentrated in the coastal provinces and countrywide network expansion was focussed on linking the interior in the west. As neither activity has kept pace with the country's double-digit growth in the demand for freight movement there was little scope for building dedicated container railways to link the coastal ports with the interior. Already the existing railway network has become too overloaded to undertake a major role in handling ISO containers, especially given its three major overriding tasks of: serving the heavy industries located in the northeast; moving increasing volumes of coal from the north and west to the south and east; and transporting raw materials (minerals) from the western extension of the network into the interior to manufacturing bases in the east.

The prospects for using the railways for containers are diminished further by congestion on major

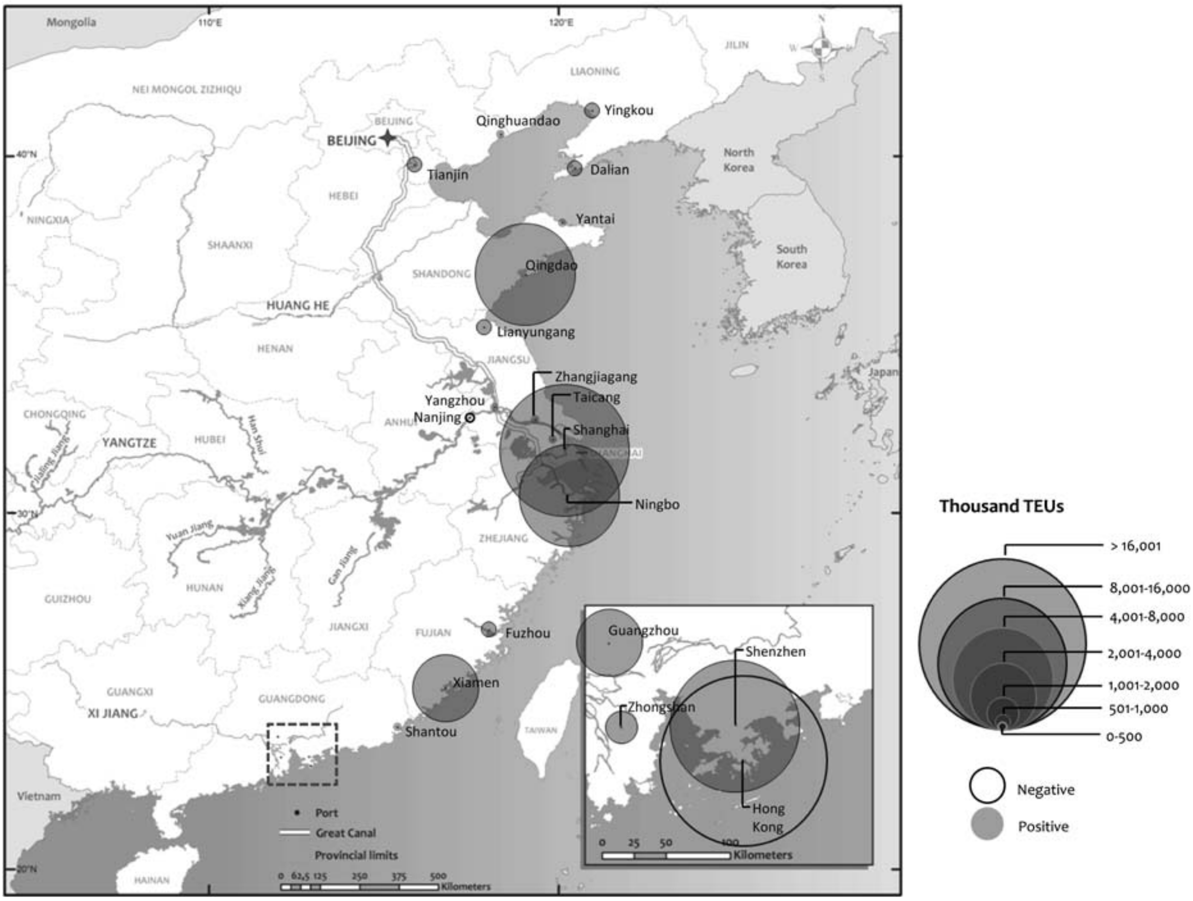


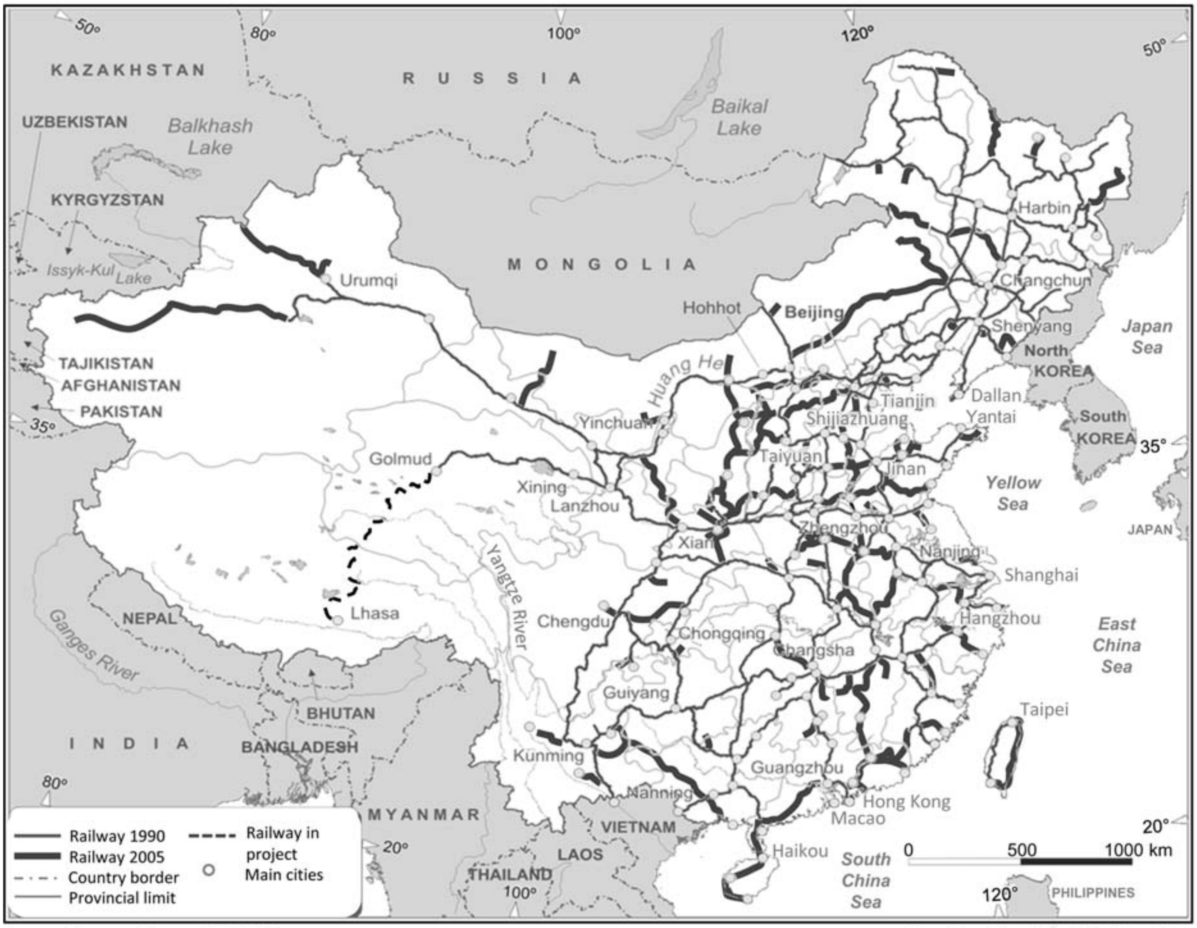
Fig. 3 Shift-share analysis of ports based on the division of the total throughput in 2005 according to 1990 percentages (*Source*: Based on data from CIY (1990–2006))

railway axes, particularly in coastal urban regions, because the anticipated delays would seriously undermine supply chain operations. These problems are further compounded by antiquated booking systems for reserving specialized rolling stock to meet immediate demands for container movement. Similarly, the overall pattern of port development is difficult to relate to the development of the high-specification motorway system. Over the period of review this has grown from 522 km in 1990 to 41,000 km in 2005 but many inland connections, particular to the western interior, are still incomplete (Fig. 5). Indeed, the road transport industry is still hard pressed to assist in the long-distance, internal movement of containers.

These difficulties in relating China's port configurations to other transport patterns on a national basis are resolved by adopting a regional approach. The rudiments of this regional division of China have long been with us, as recognition that the country needed a northern port, central port and southern port appeared in Sun Yat Sen's transport plan for China promulgated in 1919 (Rimmer 1997a). As this triple split has been an enduring feature of China's geography, three regional port ranges are identified:

- The northern range around the Bohai Rim;
- The central range focussed on the Yangtze River Delta; and
- The southern range centred in the Pearl River Delta (Fig. 6).

This regional breakdown is a bonus because it provides an opportunity to compare the efficacy of the universal port patterns in three different arenas. Between 1990 and 2005 the fortunes of these arenas have varied with the northern and central ranges



Source : Zhongguo Dituce, 1990-2005

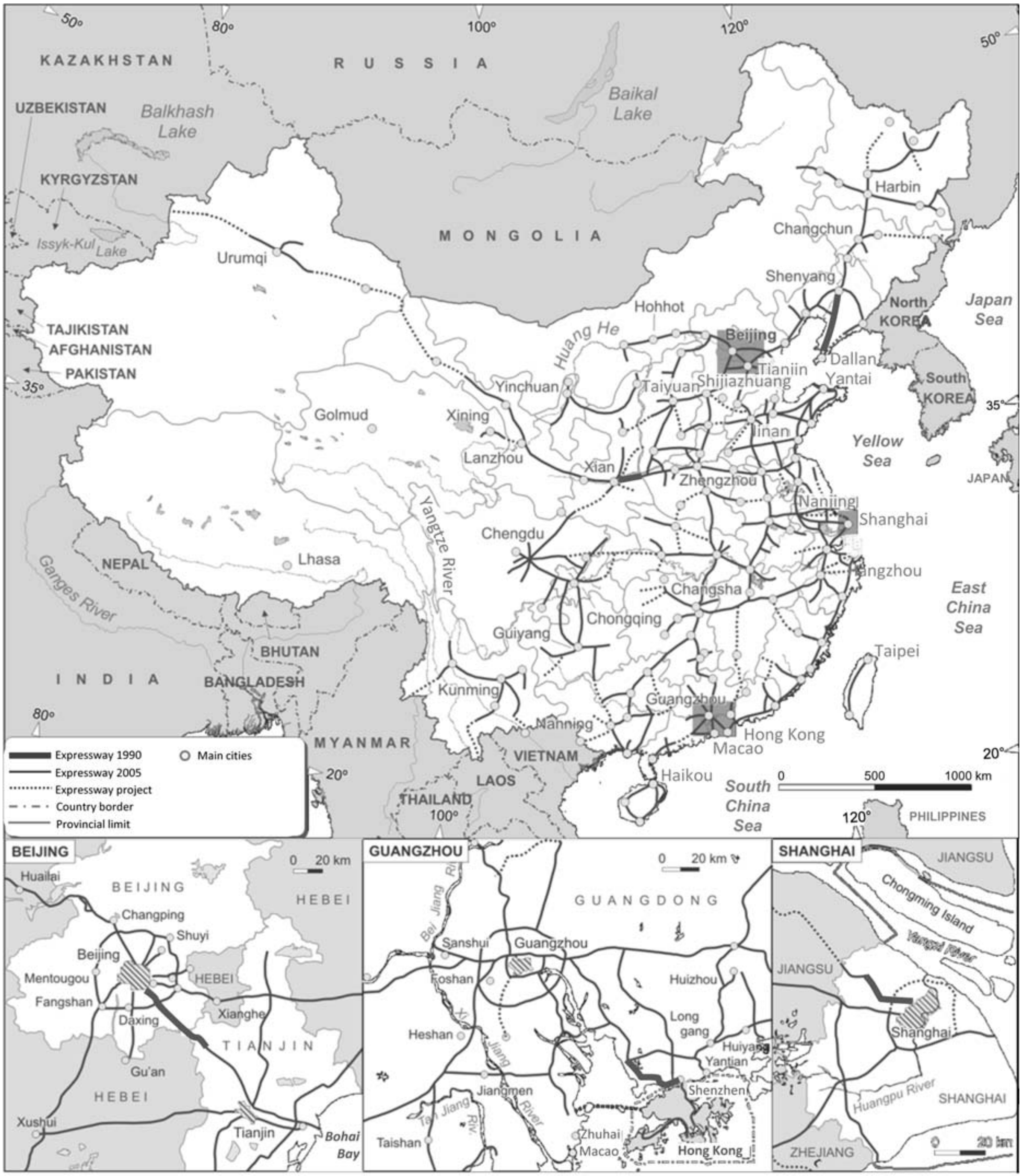
Map: Marc Girard, Émilie Dufour, 2008

Fig. 4 Railway map, 1990–2005, showing additions since 1990 in bold

making relative gains at the expense of the southern range, which still retained >50% of throughput (Table 1). The central range, however, had moved decisively ahead of the northern range, suggesting that container throughput offers a sensitive barometer of regional differences in economic development within China.

These relative changes in the importance of individual port ranges have been accompanied by shifts in the importance of individual modes in moving container inland. As noted, it is possible to distil the nature of modal shifts from data from *Zhongguo Jiaotong Nianjian* on inland movements of containers (ZJN 1991–2006). Given only 2.4 million TEUs (slightly >5% of the total) were handled by rail in 2005, the elaborate plans for railway load centres outlined by Loo and Hook (2002, p. 231) have been largely stillborn. Consequently, the railways are not considered further in discussing container-related dynamics in China. Instead, attention is focussed on data for container movements by water and road; regrettably, no distinction is made between inland waterway and coastal shipping in the water segment. Both the transport of containers by water and road transport experienced phenomenal growth during the period of review.

Water transport increased progressively from 0.2 million TEUs in 1990 to 19.4 million TEUs in 2005 by offering end-to-end intermodal transport services between ocean and inland ports, including services between deep-sea mother ships and short-sea feeder vessels. This enormous increase reflected: (a) the modernization of 7,000 km of navigable inland waterways (including a section of the imperial Canal



Source : Zhongguo Dituce, 1990-2005

Map : Marc Girard, Émilie Dufour, 2008

Fig. 5 Motorway map, 1990–2005 showing additions since 1990 in bold

between Beijing and Hangzhou); (b) additional quays at Chongqing, Wanzhou, Wuhan, Wuhu and Maanshan; and (c) an ability to handle 1000-ton vessels on 950 km of the system. These initiatives have been embodied in successive Five-Year Plans since 1996 to open access to interior regions with the aim of boosting industrial development and reducing economic disparities with the coastal provinces.

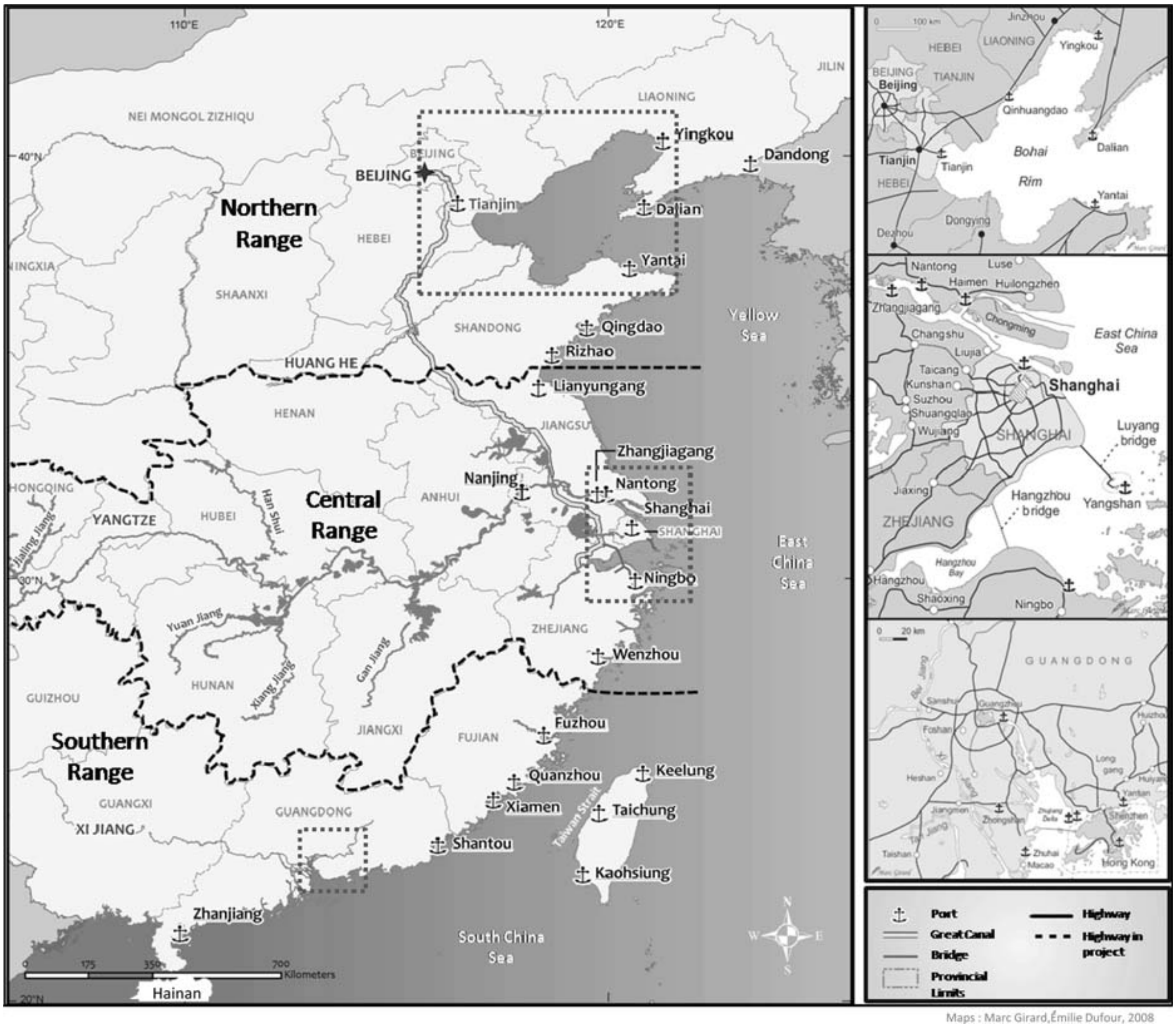


Fig. 6 Regional port ranges in China

Table 1 China's port range totals, 1990 and 2005

Port range	1990		2005	
	Thous TEUs	%	Thous TEUs	%
Northern	568.6	9.0	15,047.0	16.8
Central	506.5	8.0	25,669.7	28.7
Southern	5,251.3	83.0	48,669.0	54.5
Total	6,326.4	100.0	89,385.7	100.0

Note: These figures derived from totalling individual ports exceed the aggregate total given for China in the world container port traffic by country. The port of Fuzhou is excluded from the national total in both 1990 and 2005

Source: CIY (1992, 1993, 2007, 2008)

Belatedly, a short-sea shipping program was initiated to offset congestion on the roads; further improvements were also made to the Heilongjiang, Yangtze and Zhujiang river systems.

Parallel container throughput figures for road transport are 0.3 million TEUs in 1990 and 24.6 million TEUs in 2005. Representing the land leg for containers loaded and unloaded at China's maritime gateways, container throughput by road surpassed water transport as the leading mode in 2000 (Fig. 7). As the result of attracting 60% of all government expenditure during the period under review, the total length of roads had increased from 1.2 million km in

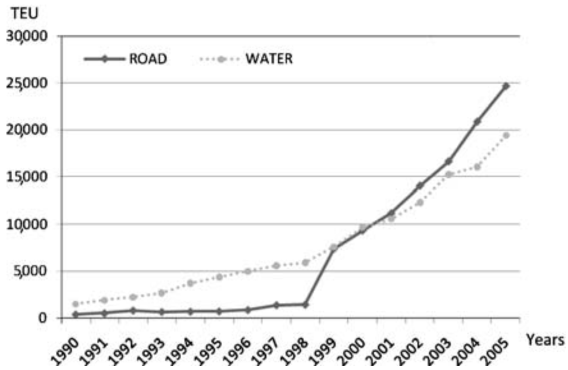


Fig. 7 Container movements by water and road transport in China, 1990–2005 (*Source*: ZJN 1991–2006)

Table 2 Container throughput by water and road transport in China's three port ranges, 1990 and 2005

Range	1990		2005	
	Water Thous TEUs	Highway Thous TEUs	Water Thous TEUs	Highway Thous TEUs
Northern	45.4	116.8	1,606.0	7,061.8
Central	26.8	114.5	12,682.3	12,527.9
Southern	126.3	41.5	5,086.9	5,059.7
Total	198.5	272.8	19,375.2	24,649.4

Source: ZJN (1991–2006)

1990 to 1.9 million km in 2005. Much of this network, however, was unattractive to container transport as 65% had design speeds <40 km/h, carriage widths of 3 m or less, and surface conditions were poor.

Once these national data on water and road transport are distilled into the three port ranges the need to discuss their varying roles on a regional basis is recognized. Inland penetration by containers had intensified in all three ranges between 1990 and 2005 (Table 2). The marked difference between the three ranges has been the rapid rise of road transport in the northern range; water and road transport, however, split the task equally in the central and southern ranges. These variations are now pursued in greater detail.

Northern port range

Between 1990 and 2005 port patterns within the northern range remained within the centralized phase of the model with ports spread at intervals around the Bohai Rim serving clearly defined hinterlands. Over

Table 3 Container ports in China's northern range, 1990 and 2005

Port	1990		2005	
	Thous TEUs	%	Thous TEUs	%
Dalian	131.3	23.1	2,655	17.6
Yingkou	0.0	0.0	633	4.2
Qinhuangdao	4.0	0.7	100	0.7
Tianjin	286.0	50.3	4,801	31.9
Yantai	11.9	2.1	551	3.7
Qingdao	135.4	23.8	6,307	41.9
Total	568.6	100.00	15,047	100.00

Source: CIY (1992, 2007)

the period the share of the national total increased from <9% to almost 17% buoyed by the revival of trade across the Yellow Sea with South Korea and Japan (Table 1).

Continuing development of the existing major industrial centres and gateways for north-eastern China's international trade enabled the range's three pre-eminent ports to consolidate their positions—Dalian, Tianjin and Qingdao (P4 in the model of universal port patterns shown in Fig. 2). There was some shuffling in their relative importance (Table 3). Despite Tianjin's proximity within 200 km of Beijing, Qingdao moved ahead of its rival as the range's leading port. In part, this occurrence stems from China Ocean Shipping (Group) Company (COSCO) changing Qingdao from a bulk shipping port into a container port to take advantage of the port's natural ice-free and silt-free deepwater facilities (Comtois and Rimmer 2004).

An examination of container movements in the northern ports range shows marked differences by mode (Table 4). Water transport had increased from 45,000 TEUs in 1990 to 1.6 million TEUs in 2005, but its growth was confined exclusively to the coastal provinces, particularly Tianjin, Liaoning and Shandong provinces. Road transport grew from almost 117,000 TEUs in 1990 to over 7 million TEUs in 2005 with Shandong province having a greater throughput than Tianjin. Highway movements remained concentrated around the Bohai Rim with six of the remaining seven provinces within the northern range now handling containers by road compared with none in 1990. Thus, by 2005 road transport has become the leading mode for moving containers within the northern port range.

Table 4 Water and road transport within China's northern port range, 1990 and 2005

Province	1990		2005	
	Water Thous TEUs	Highway Thous TEUs	Water Thous TEUs	Highway Thous TEUs
Bohai Rim				
Liaoning	8.3	36.4	285.2	1874.0
Beijing	0.0	6.5	0.0	44.6
Tianjin	0.0	46.8	285.8	1,779.5
Hebei	8.3	5.1	0.0	178.9
Shandong	28.8	22.0	1035.0	3,078.5
Sub-total	*45.4*	*116.8*	*1,606.0*	*6,955.5*
Other provinces				
Heilongjiang	0.0	0.0	0.0	22.4
Jilin	0.0	0.0	0.0	25.1
Nei Mongol	0.0	0.0	0.0	6.8
Shanxi	0.0	0.0	0.0	3.7
Shaanxi	0.0	0.0	0.0	47.4
Gansu	0.0	0.0	0.0	0.9
Total	45.4	116.8	1,606.0	7,061.8

Note: No traffic was recorded in Ningxia Province in both 1990 and 2005

Source: ZJN (1991–2006)

Central port range

Between 1990 and 2005 port patterns in the central range moved resolutely from the centralized phase to the decentralization phase with the promise of deconcentration to come. Over the period under review its national share of container throughput more than tripled from almost 8% to over 28%, reflecting its major role in the country's increasing participation within the world economy (Table 1).

The key feature was the erosion of Shanghai's total dominance by the appearance of the new decentralized ports (P4) of Lianyungang, the origin of the Trans-China Railway (TCR), a string of Yangtze River centres and, more importantly, Ningbo, which has a shared hinterland with Shanghai (Table 5). Ningbo's throughput exceeded 5 million TEUs in 2005 and is expected to grow relatively faster than Shanghai (P2 in the model) due to "its natural endowments (particularly depth of water), price (especially in terms of recovering the cost of capacity expansions) and quality of service improvements that are predicted to emerge as the result of currently planned enhancements to inland transport infrastructure and logistical systems" (Cullinane et al. 2005, p. 331). The port is also likely to be further buoyed by the local port authority's agreement with the Hong Kong-based Hutchison Port Holdings to provide new container terminals.

Table 5 Container ports in China's central range, 1990 and 2005

Port	1990		2005	
	Thous TEUs	%	Thous TEUs	%
Lianyungang	8.6	1.7	1,005.0	3.9
Shanghai	456.1	90.0	18,084.0	70.4
Zhangjiagang	0.0	0.0	377.1	1.5
Taicang	0.0	0.0	250.9	1.0
Yangzhou	0.0	0.0	157.1	0.6
Nanjing	41.8	8.3	587.7	2.3
Ningbo	0.0	0.0	5,208.0	20.3
Total	506.5	100.0	25,669.7	100.0

Source: CIY (1992, 1993 and 2007)

The threat of Ningbo's impressive development may have been over stated, particularly as its dominance is limited narrowly to Zhejiang province (Comtois and Dong 2007). Nevertheless, this intensified competition has prompted the Shanghai municipal government to respond to the implicit threat by dispersing the city's economic activities to bolster its dominant position in the competitive market, which declined from 90% in 1990 to 70% in 2005. The municipal authorities have relocated some manufacturing activities to neighbouring provinces offering lower land costs and special economic zones. This move has enabled the city to concentrate on trade and logistics-related services and investment in infrastructure to handle an increased container throughput.

The other boost to Shanghai's pre-eminence in the central port range has been the penetration of containerization inland along the Yangtze River. COSCON, a subsidiary of China's leading shipping company, has forged a connection between the deep-sea ports and a string of river ports and reinforced it by establishing offices and depots, unifying controls over containers and strengthening documentation services. Consequently, there has been an increased amount of containerized cargo handled on the Yangtze in a line-bundling service between Chongqing and Shanghai (Notteboom 2007). These developments have led to the Yangtze becoming China's 'automobile corridor'. As transport costs by water are 20–30% cheaper per kilometre than transport by road, automobile-manufacturing plants at Chongqing, Wuhan and Nanjing are making use of roll-on-roll-off ferry terminals to transport 10% of their output. This activity is reflected in the spread of container movements across inland provinces during the period under review.

The handling of containers by water increased from <27,000 TEUs in 1990 to over 12.1 million TEUs in 2005 (Table 6). Much of the throughput of containers handled by water transport occurred within the coastal provinces. However, there had been a spread of container handling by water into Chongqing, Henan, Hubei and slightly into Sichuan, reflecting heavy investment in selected river ports within the Yangtze River system by Sinotrans (China National Foreign Trade Transportation (Group) Corporation).[1]

Containers handled by road transport in the central range experienced similar explosive growth to water transport as throughput grew from over 114,000 TEUs in 1990 to 12.2 million TEUs by 2005 (Table 6). Again most throughput is concentrated in the Lower Yangtze with only Zhejiang province handling more containers by road than water. Five of the eight provinces outside the Lower Yangtze handled containers by road and, with the exception of Chongqing, was the preferred mode to water transport.

While these modal shifts were occurring, the Shanghai Port Authority was in the process of deconcentrating some of its container activities to Hangzhou Bay where the new Yangshan port was opened for traffic. As it was not opened for traffic until December 2005 it had little impact on the year under review. However, the port is expected to handle over 20 million TEUs annually by 2025.

Table 6 Water and road transport within China's central port range, 1990 and 2005

Province	1990		2005	
	Water Thous TEUs	Highway Thous TEUs	Water Thous TEUs	Highway Thous TEUs
Lower Yangtze				
Shanghai	0.0	85.3	11,307.2	8,842.1
Jiangsu	17.5	10.4	542.1	243.6
Zhejiang	9.3	11.3	182.3	3,058.9
Anhui	0.0	0.0	116.8	62.7
Sub-total	*26.8*	*107.0*	*12,148.4*	*12,207.3*
Others				
Henan	0.0	7.3	95.0	0.7
Hubei	0.0	0.0	42.3	8.4
Hunan	0.0	0.0	0.0	60.4
Sichuan	0.0	0.2	0.4	137.9
Chongqing	0.0	0.0	396.2	113.2
Sub-total	*0.0*	*7.5*	*533.9*	*320.6*
Total	26.8	114.5	12,682.3	12,527.9

Note: No traffic was recorded in Jiangxi, Qinghai and Xinjiang provinces in both 1990 and 2005

Source: ZJN (1991–2006)

Southern range

Between 1990 and 2005 port patterns in the southern range also moved decisively from the centralized phase to the deconcentration and decentralization phase. While the range still has the largest throughout of TEUs its overall share of the national total has declined precipitately from 83% to 54% (Table 1). Much of this change is attributable to Hong Kong's altered position.

In 1990 Hong Kong's dominance was virtually complete as the then de facto economic capital of

[1] Founded in 1950, Sinotrans operates under the direct administration of State-owned Assets and is engaged both domestically and internationally. Sinotrans also delivers documents, packages and heavyweight freight and acts as an agent for other international express services providers.

Table 7 Container ports in China's southern range, 1990 and 2005

Port	1990		2005	
	Thous TEUs	%	Thous TEUs	%
Fuzhou	0.0	0.0	840	1.7
Xiamen	30.0	0.6	3,342	6.9
Shantou	0.0	0.0	103	0.2
Shenzhen	40.0	0.8	16,197	33.3
Hong Kong	5,100.6	97.1	22,427	46.1
Guangzhou	80.7	1.5	4,685	9.6
Zhongshan	0.0	0.0	1,075	2.2
Total	5,251.3	100.0	48,669	100.0

Note: In 2005, a figure has been added for Fuzhou

Source: CIY (1992, 2007, 2008)

China (Table 7). Capitalizing on its strategic location, Hong Kong had prospered because of its burgeoning industrial sector, supported by massive direct foreign investment attracted by favourable conditions for industrial production. Land had been reclaimed along the coast to provide unique opportunities for export-oriented industries to develop at coastal sites within adjacent areas of the Mainland (Rimmer 1992). In the process Hong Kong secured a large volume of transhipment traffic from the river trade that developed from these sites that were linked to terminals and locations within its harbour serviced by barges. Hong Kong's pre-eminence resulted in only two other southern range ports—Guangzhou and Xiamen—handling small amounts of containerized traffic.

Fast-forwarding to 2005, Hong Kong's overall share of the southern range had declined dramatically to 46% compared with over 97% fifteen years earlier. Hong Kong's status has been eroded by a rash of new ports stemming from the liberalization of commercial exchanges with the former colony and the trade performance of export-oriented activities at ports within Guangdong province. The most significant changes have involved the deconcentration of activities from Hong Kong (P2 in the model) to the deepwater ports of Shenzhen (encompassing the ports of Chiwan, Shekou and Yantian) and Guangzhou, which are able to offer competing international calls (Song 2002; Loo and Hook 2002). While this set of ports undermined Hong Kong's international status, those located in the western Pearl River Delta, notably Zhongshan, are supportive because they are feeder ports and inaccessible to large container ships. Too much should not be made of these differences as many of these activities are the result of terminal operators based in Hong Kong, notably Hutchison Port Holdings, hiving-off container operations to alternative locations in the Zhujiang Delta (Comtois and Rimmer 1996; Airriess 2001).

The activities of terminal operators have extended to the further development of the decentralized outlier of Xiamen (P4), which was joined subsequently by the port of Fuzhou, with Hutchison Port Holdings involved in the former and Singapore Port Authority (PSA) in the latter. These developments could become the focus of an independent port range, possibly involving ports in Taiwan, though this is beyond the scope of the current study. Meanwhile the overall relative decline of ports in the southern region relative to the other port ranges has been attributed to the failure of export manufacturing to keep pace with that in the northern and central port ranges, especially in the western Zhujiang Delta where land transport infrastructure has remained poor.

Over the period under review the throughput of containers was almost split equally between the two transport modes. Water transport increased from 126,000 TEUs in 1990 to 5.1 million TEUs in 2005 (Table 8). All of this activity was concentrated in the four coastal provinces. Water transport maintained a slight edge over road transport, which increased from almost 42,000 TEUs in 1990 to 5.1 million TEUs in

Table 8 Water and road transport within China's southern port range, 1990 and 2005

	1990		2005	
	Water Thous TEUs	Highway Thous TEUs	Water Thous TEUs	Highway Thous TEUs
Fujian	11.7	11.9	599.6	1,249.2
Guangdong	110.6	29.6	4,227.5	3,597.2
Guangxi	3.6	0.0	94.5	157.9
Hainan	0.4	0.0	165.3	55.4
Sub-total	*126.3*	*41.5*	*5,086.9*	*5,059.7*
Others	0.0	0.0	0.0	0.0
Total	126.3	41.5	5,086.9	5,059.7

Note: No traffic was recorded in Guizhou, Yunnan or Tibet Provinces in both 1990 and 2005

Source: ZJN (1991–2006)

2005. Again, all of the activity was concentrated within four provinces as no record of container throughput was recorded for the inland provinces.

Rider

Massive though the changes in container-related dynamics that have been reported here, it is important to add the rider that China still faced major infrastructure challenges beyond 2005. Manners-Bell (2004), drawing on a *Transport Intelligence* report, highlighted that no less than 10 logistics challenges had to be overcome in the medium-term. These ranged from poor infrastructure through over-regulation, inhibiting bureaucracy and culture, poor training, limitations on information and communication technology outside major areas, energy supply problems, underdeveloped domestic transport industry, high transport costs, poor warehousing and storage facilities, regional imbalances to domestic trade barriers.

Since 1990 the development of China's road container transport has been affected by a restrictive licensing system that has been limiting cross-border provincial freight movements (Chung 2004). Traffic surveys indicate that a high percentage of trucks are stalled at provincial border crossings, which not only increases waiting time but also limits the number of round-trips. Further, road tolls are very high, accounting for nearly 20% of the total haulage cost. Besides, the number of custom clearance points has increased from 28 in both Central and Northern China to 117 in Southern China, mainly in Guangdong province (DSC 2003). Not surprisingly, trucking services are often more expensive than waterways Road container transport costs between Chongqing and Shanghai amount to US$2,750 per TEU while river transport cost is estimated at US$370 per TEU for the same distance (YRP 2006).

A further factor affecting the development of the road container industry is that goods produced in western China are not competitive in the market place compared with those derived from Guangdong, Jiangsu, Zhejiang, and Shanghai. More than 90% of imports and exports in coastal provinces comprise port/port hinterland traffic that originates or terminates within 300 km of the coast. Regular journeys into the countryside beyond this range are perceived as being 'inconvenient' by trucking companies. Remoteness from ocean ports often prevents manufacturers meeting deadlines, which is a severe constraint in the context of just-in-time operations. The value that companies impose on predictability of transport times and schedules determines how new transport infrastructure will affect business investment and location decisions and, in turn, generate both traffic and economic growth. Nevertheless, a series of inland dry ports are emerging as crucial inland freight distribution points such as Zhengzhou, Wuhan, Xian, Chongqing, Chengdu and Lanzhou which suggests an elaboration of the fifth phase of the universal model of port patterns is occurring in China.

Conclusions

Container movements have provided an important marker of the impacts of the massive restructuring of China's economy between 1990 and 2005. The analysis of patterns in the northern, central and southern port ranges closely mirror pronounced shifts in the country's economic geography, and reactions and responses to major trends in the world economy. There have been fresh opportunities to move containers for river and coastal shipping, and road transport—if not rail—in the hinterlands behind China's port façades, which have arisen from new trends in the international organization of production and the country's industrial structure.

The invocation of the universal model of port patterns to track developments within China's northern, central and southern ranges is always going to be a contentious issue. The purpose of invoking the model is to focus on the China case and to pinpoint, and then explain, deviations in an economical way, given the large number of ports, variety of modes and vast terrain being considered. Its application does not mean that China has been necessarily swept up in the inexorable evolution of spatial patterns of port locations with the improvement of internal accessibility and the accompanying process of dominance ranking. There are certainly throwbacks to earlier phases as new ports enter and jostle for a place in the sun, particularly in the southern range.

There may be important distinctions between imports and exports that require further investigation. Currently, multinationals concentrate imports on a single port for inland distribution within a port range, whereas exports are consolidated at the point of production or at the port of embarkation. This pattern suggests that if multinationals are to serve both import and export markets simultaneously, they may have to integrate their production and logistics functions at regional hubs connected to fully-fledged multimodal trunk routes.

Looking ahead, more overlapping of China's port ranges may occur. Ports in the southern range are consciously extending their tentacles to tap the upper reaches of the Yangtze River system. If this probe is successful container movements destined for Shanghai could be diverted to the southern range. This possibility underlines that the port ranges are temporary phenomena and hinterlands need to be revisited at the beginning of any study of China's container-related dynamics.

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