Density economies and transport geography: Evidence from the container shipping industry

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14 December 2016

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December 2016

Abstract: By exploiting the 1995 Hanshin earthquake, which occurred in Japan, as an exogenous shock to the container shipping industry of northeastern Asia, this study provides an empirical relevance of the role of transport density economies in shaping the transport geography. The Hanshin earthquake caused severe damage to the Kobe port. Consequently, its container throughput was largely diverted to the nearby Busan port, which scaled up in this windfall. Focusing on the long-term growth of major port areas in northeastern Asia, we find that extensive diversions of container traffic occurred after the earthquake from Tokyo and Yokohama ports to Busan port, although container shipping operations in Tokyo and Yokohama ports were not directly affected by the earthquake. We interpret the economies of transport density benefitting Busan as the underlying mechanism; increased transport density allows Busan port to further enlarge its hinterlands and reshape the transport geography. We also find that the unintended diversions of container shipping lead to a structural change of manufacturing pattern in related regions.

Key words: hub port; density economies; transport geography; earthquake
JEL classifications: R40; L92; F19

1 Introduction

The traditional New Economic Geography models consider the level of unit transport costs as exogenously given and independent of the spatial structure of the economy (Fujita et al., 1999). This is, however, implausible since the spatial distribution of economic activities directly affects trade flow, and therefore, the unit shipping costs decrease in the presence of density economies of transportation (Behrens et al., 2006). For instance, in the context of container shipping industry, density economies arise because a higher transport density on a route allows the carriers to use larger vessels and to operate this equipment more intensively; in addition, higher transport densities allow for more intensive and efficient use of port facilities and related services that serve the route, leading to lower time and costs per unit handled.

The port of Singapore is a large hub port linked to international trunk routes with high frequency of ship calls; consequently, travel time (including waiting time at port) to Japan from Singapore is only half of that from Jakarta, although the respective distances from Jakarta and Singapore to Japan are similar (Shipping Gazette, 1997). Also, based on the estimates of Mori and Nishikimi (2002), monetary transport costs from Japan to Manila (a non-hub port) is, on average, 22.6% higher than to Hong Kong (a hub port), though they are of similar distance to Japan. Additional evidence can be found in Braeutigam et al. (1982), Caves et al. (1984), Brueckner et al. (1992), and Xu et al. (1994) for other transportation modes.

Nevertheless, given the solid empirical evidence that transport density is negatively associated with (both monetary and time) unit transport costs, few empirical studies examine the role of transport density in shaping the transport geography, as predicted in theory (Mori and Nishikimi, 2002; Mori, 2012). Increasing returns in transportation (here, we refer to density economies in transportation[1]) provide an incentive for collective cargo transport and hence stimulate the development of trunk routes, which leads to the endogenous formation of trunk links and hub-spoke structure of transportation; economies of transport density could thus be the primary source of industrial localization (Mori, 2012).

By employing a novel origin-destination (OD) type container traffic dataset between Japan's

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[1] Mori (2012) considers two kinds of increasing returns in transportation: distance economies and density economies. We focus only on density economies in the current study, and will show the reasons for this strategy in Section 3.

prefectures (or, the locations of shippers) and its domestic ports for exporting/importing cargo, and exploiting the exogenous shock on northeastern Asia's container cargo flows due to the Hanshin earthquake, we examine the role of economies of transport density in shaping the spatial structure of transport network.[2]

The Hanshin earthquake caused severe damage to the Kobe port (northeastern Asia's largest container port before the earthquake). Consequently, its container traffic largely diverted to the closest major container hub-port, Busan, reintegrating the container transportation market in northeastern Asia. Busan benefited from this exogenous windfall of container traffic, and thus significantly expanded its scale of container transportation and increased the transport density. Given the change in transport density, transportation costs[3] from/to Busan were expected to decrease because of the existence of density economies. As a result, it became possible for Busan port to enlarge its hinterlands by offering lower shipping charges and lower transportation time. Since Busan port is historically the leading port of South Korea by national strategy (that is, the whole of South Korea is the hinterland of Busan port), and since North Korea is not open for free international trade (that is, North Korea is not considered to be a valid hinterland of Busan port, even if the shipping charge is sufficiently low), Japan naturally becomes the potential new hinterland of Busan port for a global gateway, as most of Japan's territory is geographically close to Busan port (pair-distances range from 200–1,300 kms, except Okinawa prefecture). Furthermore, longitudinal OD type container traffic data (at the prefecture level) are available in Japan, which provides us the opportunity to test the impact of Hanshin earthquake on port choice and transport network, concerning the density economies in container shipping.

By establishing a simple port choice model, we examine the hypotheses by examining the dynamics of shippers' port choice behavior in Japan. Precisely, we choose northern Japan as the study area (see Section 4.1 for a detailed explanation on this research design). We find that the container shipping market in northern Japan experienced a dramatic change after the Hanshin earthquake. In the decade before the earthquake, more than 80% of the export/import container cargoes in northern Japan were handled by the Keihin port area (i.e., Tokyo and Yokohama ports) (another major port area in northeastern Asia, except Hanshin (i.e., Kobe and Osaka ports) and

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[2] As defined by *Council on Foreign Relations*, northeastern Asia includes Japan, South Korea and North Korea.

[3] Container transportation costs include not only shipping costs on sea, but also port terminal and handling charges on land.

Busan).[4] However, shortly after the earthquake, the situation within northern Japan changed significantly. Regions close to Keihin port area (*assumed to be the stable hinterlands of Keihin port area*) do not change the port choice strategy; however, for the regions remote to Keihin port area (*assumed to be the unstable hinterlands of Keihin port area*), the share of container traffic handled by Keihin port area largely declined to approximately 40%. The remaining shipping cargoes were largely diverted to Busan port via regional ports in northern Japan for transshipment. The diversion effect is quantitatively confirmed by a standard difference-in-difference (DID) estimation focusing on the port-specific cargoes in regions remote and close to Keihin port area, and before and after the Hanshin earthquake.

We interpret these results as the consequences of strengthened density economies in Busan port, caused by the windfall of container traffic diverting from the earthquake-affected Kobe port. Expanded shipping demands in Busan allow it to develop more efficient container transportation network,[5] thus successfully enlarging the hinterlands of handling cargoes by gaining new markets which were once the hinterland of Keihin port area.

Furthermore, we provide a preliminary analysis on the impact of container traffic diversion on the relocation of economic activities. We find in the study area that after the earthquake, regions diverting their container cargoes to Busan port expanded the scale on container trade tonnage volumes, while leaving the trade values (taking the value term of manufacturing input and output as proxies) largely unchanged, compared with the selected control regions. We interpret these results as more efficient shipping systems (through the expanded Busan port) shifting economic activity in related regions toward the production of heavy goods (high weight per dollar), which is consistent with the findings of Duranton et al. (2014). Duranton et al. (2014) find that a city's stock of highways in the US is positively associated with its weight of exports, but does not affect the value of exports; cities with more highways specialize in sectors producing heavy goods (high weight per dollar).

This study contributes to two bodies of literature. First, to our knowledge, we are the first to provide an empirical relevance of the role of transport density economies in the transport geography,

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[4] Throughout the paper, Keihin port area refers to Tokyo and Yokohama ports (these two ports are geographically close to each other; around 30 kms), Hanshin port area refers to Kobe and Osaka ports (these two ports are also around 30 kms to each other); Busan port area refers to Busan port only, since there is no second major port close to it.

[5] For example, Busan port offers more international trunk routes, lower shipping rates for not only trunk line services but also feeder services, and shorter transportation time (including waiting time at port).

as theoretically confirmed by Mori and Nishikimi (2002), Behrens et al. (2006), and Mori (2012). Existing empirical studies find a negative relationship between transport density and unit transport cost (e.g., Braeutigam et al. (1982) and Brueckner et al. (1992)), but do not provide implications and evidence regarding the spatial scope of transportation activities. In the current study, we find that the transport density may self-adjust the transport cost and thus reshape the transport geography.

Second, our analysis contributes to the literature on the empirical relevance of multiple equilibria (e.g., Davis and Weinstein, 2001, 2008; Bosker et al., 2007; Redding et al., 2011; Bleakley and Lin, 2012). Hitherto, this literature has been far from conclusive. Our work is most closely related to Redding et al. (2011), who examine the development of German airports before and after the division in World War II, and identify the shift of the air hub from Berlin to Frankfurt as the multiple equilibria in industrial locations. However, the current study differs from Redding et al. (2011) in two respects. First, we use port-prefecture OD data while they relied on the aggregate airport-level traffic variation; one important advantage of our disaggregate OD data approach is that it allows us to identify the source and heterogeneity of transport traffic change and exploit the underlying channel. Second, we examine related issues from a cross-country perspective, rather than a closed-economy one, since the leading hubs of container shipping, as well as air traffic, are generally positioned internationally and globally. Restricting the related analysis to a one-country perspective potentially leads to a one-sided analysis.[6]

The remainder of this paper is organized as follows. Section 2 presents the background information on the Hanshin earthquake and port hierarchy of Japan and northeastern Asia. Sections 3, 4, and 5 present the hypotheses, empirical strategies, and findings, respectively. Finally, Section 6 concludes the study.

2 The Hanshin earthquake and port hierarchy of Japan and northeastern Asia

On January 17, 1995, southern Japan was struck by the Hanshin earthquake, which measured seven on the seismic intensity scale. The city of Kobe, located 20 kms away from the epicenter and

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[6] It would be difficult to exploit the channel of post-1995 container cargo diversion in northern Japan if we consider only Japan's domestic ports and ignore the role of Busan port in South Korea.

with a population of 1.5 million, suffered maximum damage. Approximately, 6,434 persons lost their lives, of whom about 4,600 were from the city of Kobe (Kobe City FIRE Bureau, 2006).

As a major port city of Japan, Kobe is historically an important component of the Hanshin economic zone. The port of Kobe was Japan's first container port with high standard container berths, or over-Panamax, since 1967. During the late 1970s and the 1980s, with the generalization of scale economies on containerization and the development of hub-and-spokes networks, the port of Kobe became the main gateway seaport in Asia, and was at the top of the Japanese (maritime) hierarchy (Guerrero and Itoh, 2016). The container handling volumes at Kobe port between the late 1970s and early 1980s made it one of the leading ports in the world.[7] Although large container hubs emerged in neighboring countries/regions (South Korea, Taiwan, and Hong Kong) from the late 1980s, diverting container lines from Japanese ports, Kobe port was still one of the leading container ports in Asia. However, the Hanshin earthquake acted as a catalyst of the downgrade of Kobe port (Guerrero and Itoh, 2016).

After the earthquake, the role of Kobe port in both Japan and northeastern Asian port hierarchy underwent a significant change. Figure 1 (a) shows the international container cargo flow for the major ports in Japan (including the traffic of trading cargo and international transshipment cargoes; the container cargoes inside Japan are not included). For both exports and imports, Kobe ranked top in Japan's port hierarchy before the Hanshin earthquake in 1995, while after the earthquake, Yokohama and Tokyo became the leading ports for exports and imports, respectively, leaving the container traffic of Kobe stagnated. By 2014, container exports and imports of Kobe stabilized at roughly 80% of the pre-earthquake level (Figure 1 (a)).[8]

Before the earthquake, Kobe performed as a major hub port for international container transshipment. In 1994, 31.6% of the container cargo in Kobe port was international transshipment; however, as the most vulnerable sector of the ports' activities, the share of international transshipment cargo in Kobe declined to about 4% in the late 2000s and further decreased to 0.1% in 2011 (Figure 1 (b)). The international transshipment cargo had shifted to the port of Busan (the

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[7] Container cargo became the major form of maritime shipping since the 1970s; for example, 90.3% of the throughput (measured by tonnage) of Busan port was handled by containers in 2010 (Busan Port Authority, 2011).

[8] The regional ports (i.e., small-scale ports) in Japan developed during this period. Before the late 1980s, almost all the international container cargoes in Japan were handled by the top five ports (i.e., Kobe, Tokyo, Yokohama, Nagoya, and Osaka). From the early 1990s (in particular, after the Hanshin earthquake), regional ports (referred to "others" in Figure 1 (a)) gained a greater market share.

leading port of South Korea, accounting for 93% of the national total container traffic in 1995 and 73% in 2010 (Busan Port Authority, 2011)), the closest major hub port to Kobe.[9]

After the Hanshin earthquake, the hub function of Kobe port as the northeast Asian gateway was largely replaced by Busan port, though the damaged facilities of Kobe port were fully and quickly recovered in March 1997 (Guerrero and Itoh, 2016). Busan's international transshipment traffic received a major boost as a result of the diversion of several trunk lines from Kobe port (Fossey, 1997). International transshipment cargoes in Busan port accounted for only 6% of its total container cargo in 1992; however, this figure increased to 45% in 2011 (Figure 1 (b)). Figure 1 (c) further confirms this stylized fact. Immediately after the earthquake, during the period 1994–1995, the total container traffic of Kobe port decreased by 1.4 million TEUs (Twenty-foot Equivalent Units), while that of Busan increased by 1.3 million TEUs. Given that the traffic of other major ports in eastern Asia (Kaohsiung, Tokyo, Yokohama, Shanghai) did not significantly fluctuate in 1995, and the growth of Busan port in 1995 was significantly higher than that in previous years (Figure 1 (c)), we may suppose the container traffic in Kobe was mainly diverted to Busan, but not others.

As a result, Busan port became the leading hub port of northeastern Asia after the Hanshin earthquake. Table 1 shows the number of international trunk routes for the major port areas of northeastern Asia in 2012. We find the number of routes is significantly higher in Busan than in Hanshin and Keihin port areas. When looking at the ranking changes of world's major container ports, Kobe ranked 5th in 1990, and fell behind the top 10 in 1995 due to the Hanshin earthquake (Table A.1). Its container traffic largely decreased and stagnated since 1995; in 2008, Kobe ranked 43rd in the world's major container ports (Busan Port Authority, 2011). Regarding Busan port, it ranked 7th in 1990 and rose to the 3rd position in 2000, becoming the top gateway port in northeastern

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[9] After the earthquake, the container cargoes of Kobe port tend to divert to Busan port rather than the major domestic ports of Japan (i.e., Osaka, Tokyo, Yokohama, and Nagoya ports) because of several reasons. First, Osaka and Nagoya ports are positioned relatively locally and the scales are significantly smaller than the other three major ports (Kobe, Tokyo, and Yokohama) in the 1990s; thus, the number of trunk routes and port facilities are not sufficient to absorb the traffic in Kobe port. Second, the main hinterland of Kobe port before the earthquake, southern Japan, especially the regions along the Sea of Japan, are relatively closer to Busan than the Keihin port area. Third, the South Korean government provided policy and financial support for the development and expansion of Busan port. Along with offering lower discounted handling costs and expanded capacity at port terminals supported by the South Korean government, Busan had been developing more direct feeder services to the regional ports in Japan since 1988 (Containerisation International, 1997). After the Hanshin earthquake, Busan port intensively established container feeder services to Japanese regional ports to enlarge its hinterlands. For the 29 Japanese regional ports with direct route to Busan port (there are 62 regional ports in Japan, for the rest 33 ports, they do not have a direct route with Busan port), 12 and 7 regional ports established their first route to Busan port in the periods of 1995–1998 and 1999–2002, respectively, while for the period of 1991–1994 (before the earthquake), the figure is only 2 (Data source: Official homepages of Japanese regional ports). Moreover, the port handling charge at South Korean ports is cheaper than that in Japanese ports. Thus, shipping companies will prefer South Korean ports when considering to establish a new shipping route to replace Kobe port after the Hanshin earthquake (Harada, 1996).

Asia, although after 2000, it dropped to the 5th position due to the rapid development of Chinese ports like Shanghai and Shenzhen (Table A.1).

Figure 1 (d) shows the relative scale of the three largest port areas in northeastern Asia (i.e., Keihin, Hanshin, and Busan port areas). The sizes (in TEUs) of the three port areas are comparable in 1994, that is, before the earthquake. Taking the total annual container traffic of the three port areas as 100%, Busan, Hanshin, and Keihin accounted for 29%, 33%, and 38%, respectively; however, in 2011, Busan accounted for 59%, while Hanshin and Keihin port areas accounted for 16% and 25%, respectively. Thus, the share of Hanshin and Keihin port areas declined by 17% and 13%, respectively, while that of Busan expanded by 30%. The relative scale of Keihin port area also shrank, although it was not directly affected by the earthquake.[10] Regarding container traffic volume, Hanshin port area showed an increase by 21% in 1994–2011, Keihin port area expanded by 68%, while Busan grew by 406%, which is remarkable (Data source: Japan Port Statistics Yearbook, various years; Drewry Shipping Consultants Ltd., 2012).

3 Hypotheses

This section provides the intuition and mechanism regarding how the density economies in transportation affect the transport geography. We begin the hypotheses with a simple framework on port choice. We assume that the economy is a two-dimensional space (expressed by rectangular coordinates) and that firms (i.e., container shippers) are located in the X axis. Precisely, firms are continuously located at (x, 0), $x \in [0, F]$ $(F > 0)$, where (0, 0) and (F, 0) are the fringe locations on the land, as shown in Figure 2 (a). In addition, there are two hub ports, located at (0, 0) and (0, c) $(c > 0)$ of the Y axis, denoted as Hub 1 and Hub 2 (Figure 2 (a)). Except the one-dimensional space in the X axis, which holds the firms (and Hub 1), and location (0, c), which holds Hub 2, other locations in this two-dimensional space are not available for economic activities, that is, they are assumed to be the sea. Each firm location has its own small-scale regional port at the same place, which is accessible to both hub ports, and feeder services are available.

To freight the container cargoes aboard (to an international destination, which is beyond this

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[10] Although not statistically tested, the post-Hanshin earthquake decline of Keihin port area (relative scale) was first noticed by Chang (2000), who found the aggregate share of Japanese regional ports increased after the earthquake and those of major ports decreased in Japan. However, Chang (2000) did not provide a detailed quantitative analysis due to data limitations.

two-dimensional space), container cargoes are loaded in the firm locations (i.e., regional ports) and then transshipped in one of the hub ports to be connected by an international trunk route. Direct delivery to the international destination without passing through a hub is assumed to incur significantly higher freight costs than that through a hub. The transport costs in the branch route (i.e., between the firm location and a hub) is proportional with the linear distance (without loss of generality, we assume the unit transport cost in the branch route is 1). The transport costs for shippers in location (*x*, 0) to Hub 1 is thus equal to *x*, and to Hub 2 is $\sqrt{c^2+x^2}$. Since $c \neq 0$, we have $\sqrt{c^2+x^2} > x$ for all the firm locations.

We assume the transport costs from hub port *i* to the international destination is negatively correlated with the transport density (denoted as d_i, $i = 1,\ 2$) in related international trunk routes (each hub has its own trunk route to the international destination, and the trunk routes are independent of each other), and the transportation distances from Hub 1 and Hub 2 to the destination are assumed to be the same and constant. The transport density of trunk routes thus becomes the unique determinant of transport costs in the trunk route between hub *i* and the destination (denoted as τ_i). If transport densities are same on both hubs, that is, $\tau_1 = \tau_2$.

The total transport cost for container shipping (passing through hub *i*) is the sum of the freight costs in the branch route (from the firm location to hub *i*) and the trunk route (from hub *i* to the destination), denoted as $TC_i(d_i, x)$, $i = 1,\ 2$, which is determined by d_i and *x*. For each shipper, two shipping routes are available. We set $TC(d_1, d_2, x)$ as the total transport cost faced by a shipper located at (*x*, 0), after making the decision of transportation route to minimize costs, that is, $TC(d_1, d_2, x) = \min\{TC_1(d_1, x),\ TC_2(d_2, x)\}$.

We assume initially the transport densities are the same for two trunk routes, which are equal to a constant d_0: $d_1 = d_2 = d_0$, $\tau(d_0) = \tau_0$. As a result, for all the firm locations, Hub 1 is preferred to Hub 2 in terms of total transport cost, because:

$$\tau(d_1) + x < \tau(d_2) + \sqrt{c^2+x^2} \quad \text{(i.e., } TC_1(d_1, x) < TC_2(d_2, x)\text{)},$$

as shown in Figure 2 (b). Therefore, we have $TC(d_1, d_2, x) = TC_1(d_1, x)$.

Based on the above setup, we perform a comparative static analysis by allowing an exogenous and positive shock on the transport density of Hub 2 from outside this transport market. d_2 is now increased from d_0 to d_0', $\tau(d_2) = \tau(d_0') = \tau_0' < \tau_0$, while d_1 remains unchanged ($d_1 = d_0$) because of the (completely) exogenous shock to Hub 2. Furthermore, we assume the following two inequalities are satisfied:

(1) $$\tau_0' + \sqrt{c^2 + F^2} < \tau_0 + F \text{, or, } TC_2 < TC_1 \text{ at } (F, 0),$$

and,

(2) $$\tau_0' + \sqrt{c^2 + 0^2} > \tau_0 + 0 \text{, or, } TC_2 > TC_1 \text{ at } (0, 0).$$

This implies the shock heterogeneously affects $TC(x)$ in the locations of $(x, 0)$ ($x \in [0, F]$). As shown in Figure 2 (c), a threshold location f_{div} exists:

$$TC(d_0, d_0', x) = \begin{cases} TC_1(d_0, x), & \text{if } x \in [0, f_{div}] \\ TC_2(d_0', x), & \text{if } x \in (f_{div}, F] \end{cases}.^{11}$$

For the firm locations of $(x, 0)$ ($x \in [0, f_{div}]$), total transport costs of container cargoes through Hub 1 is not higher than Hub 2, while for the locations that $x \in (f_{div}, F]$, related costs through Hub 2 are lower than Hub 1 because of the positive effects by the exogenous shock (as shown in Figure 2 (c)). The dotted blue line (Figure 2 (c)) refers to the change in $TC(x)$ for all the locations after the exogenous shock on d_2, that is, shippers in the locations of $(x, 0)$ ($x \in (f_{div}, F]$) may save costs by diverting the cargoes from Hub 1 to Hub 2; consequently, shippers' port choice will change after the positive shock on transport density in Hub 2.

To simplify the analysis, we assume the firms directly send their container cargoes from the firm location to either Hub 1 or Hub 2, that is, there is no sub-hub collecting cargoes before reaching Hub1/Hub2. This assumption holds when the pair distance between the firm location and the hubs is not long enough; see *distance economies* in Mori (2012) (*distance economies* refer to a decrease in transport costs per distance by longer hauling). Furthermore, we assume the locations of Hub 1 and

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[11] In the case that inequality (1) is not satisfied, then the transport density change in Hub 2 will not lead to a port choice change for all the firm locations; all the shippers still prefer Hub 1 to Hub 2. In the case that inequality (2) is not satisfied, then the transport density change in Hub 2 will lead to a comprehensive port choice change. In other words, shippers in all the firm locations will divert their cargoes from Hub 1 to Hub 2.

Hub 2 are given but not endogenously determined; consequently, the current comparative static analysis could omit the impacts of *distance economies*, since the physical distance in all respects does not change due to the positive shock on d_2.

One implication arises from this simple comparative static analysis. A change in the transport density of Hub 2 has heterogeneous impacts on the port choice behavior among locations. Regions close to Hub 1 are not affected by the expansion of container traffic in Hub 2, while regions remote to Hub 1 benefit from the expansion. Within the benefitted regions, the transport cost saving (in absolute terms) is positively related with the location's distance to Hub 1 (as shown in the dotted line of Figure 2 (c), which is equal to: $TC_1(d_0, x) - TC_2(d_0', x)$ $(x \in (f_{div}, F])$. By extending the analysis to a multi-period setting, the container cargo diversions from Hub 1 to Hub 2 due to the exogenous shock will further increase the transport density in Hub 2 (also, decrease that in Hub 1) and may further strengthen the density economies in Hub 2 and divert cargoes. However, we do not make any further assumptions, since the implication is sufficient for the purpose of the present study.

4 Research design and data

4.1 Research design

As discussed in Section 2, Busan port expanded in 1995 because of the diversion of container cargoes from the earthquake-affected Kobe port, which is expected to exogenously increase its transport density. Busan port and the shock to its container traffic in 1995 are thus consistent with the specification of "*Hub 2*" in Section 3. To test whether the expansion of Busan port leads to a spatial reorganization of transport network, as predicted by the model, we focus on the regions that are initially hinterlands of another major port area. We choose the Keihin port area (as the setup of "*Hub 1*" in Section 3) and its hinterlands as the study area. The logic of our research design is as follows.

As assumed in the model, to identify the change of firms' (shippers') port choice behavior stemming from the change in transport density, we need to ensure the port choice behavior is not affected by other factors except economies of transport density by the exogenous shock. In particular, the transport density in Hub 1 should not be affected by the exogenous shock on Hub 2 (as assumed in the model). Thus, the Hanshin port area and regions close to it are not qualified as the study area, since the port choice in this area was directly affected by the earthquake damage (i.e., the exogenous shock). This would make it difficult to distinguish between the effects of density economies and effects of earthquake destruction, even if the shippers' port choice behavior in this area was changed due to the economies of transport density at Busan port.[12]

For northern Japan, however, they are mainly the hinterlands of Keihin port area before the earthquake, and shippers in northern Japan rarely used Hanshin port area; thus, the earthquake did not directly affect the port choice in northern Japan. We may expect the diversions of port choice behavior in this region to Busan port, if any, stem from the present channel of Section 3.

We thus examine the impact of Busan port's increased transport density on firms' port choice behavior in northern Japan, which is in line with the theoretical specification in Section 3. Following the discussions on the model (also, Figure 2), we assume that "*Hub 2*" is Busan port, and "*Hub 1*" is the Keihin port area; Hanshin earthquake, as well as the container traffic diversion from Kobe port to Busan port, is the "*exogenous and positive shock to the transport density of Hub 2*". Moreover, the quasi "*X axis*" is shippers' locations in northern Japan, all the locations in this region are closer to Keihin port area than to Busan port. "*Firm locations of (x, 0)* ($x \in [0, f_{div}]$)" in the model refer to the regions close to Keihin port area, which are not affected by the shock in terms of shippers' port choice. These regions are set as the control group in the empirical analysis. On the other hand, "*firm locations of* $(x, 0)$ ($x \in (f_{div}, F]$)" in the model are the regions remote to Keihin port area, which are set as the treatment group. As predicted in the model, shippers' port choice in treatment group is supposed to be affected by the earthquake, since their container transport costs will be reduced by diverting the cargoes from Keihin port area to Busan port. More specifically, "*(0, 0)*" is Tokyo (closest prefecture to Keihin port area), and "*(F, 0)*" is Hokkaido prefecture (most remote prefecture to Keihin port area). The geographical locations of Keihin and Busan port areas, as well as regions within northern Japan, are thus fully matched to the setup in the model.

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[12] A number of existing studies examine the 1995 earthquake effects on the container traffic and hinterland of Kobe port (e.g., Chang, 2000; Itoh, 2013). They find solid evidence that the Kobe port persistently lost its shipping routes and hinterlands, in particular, on international transshipment cargoes. Looking at the container traffic data of southern Japan, the stylized facts are consistent with the opinions presented in this paper. Regions of southern Japan that are close to Kobe port are still the hinterlands of Hanshin port area after the recovery of Kobe port, while regions remote to Kobe (initially the hinterlands of Hanshin port area) diverted the container cargoes to Busan port after the earthquake (graphical evidence are available upon request).

4.2 Data

It is preferential to have the generalized (transportation) costs (both monetary costs and time costs) in each shipping route. We can thus test whether the transportation costs in the routes via Busan port significantly decline after the earthquake due to higher transport density. However, the measurement of container transportation costs is complicated, related micro-level data are not available.[13] We thus test our hypothesis based on the shippers' port choice behavior, as a kind of revealed preference. In the case that container transportation costs are significantly reduced because of economies of transport density, we expect a port diversion of container shipping from Keihin port area to Busan port.[14]

We identify the hub port choice of northern Japan shippers based on the Container Cargo Flow Survey (CCFS) conducted by Japan's Ministry of Land, Infrastructure, Transportation and Tourism (MLIT). The database details the prefecture-level trade volumes[15] (measured by tonnage; separately for exports and imports) classified by the domestic major ports proceeding the customs clearance (i.e., Kobe, Osaka, Tokyo, Yokohama, Nagoya, and the rest small-scale regional ports as unclassified) in 1985 and between 1988 and 2013 at five-year intervals (i.e., 1985, 1988, 1993, 1998, 2003, 2008, 2013). For example, for a container cargo originating from Miyagi prefecture in northern Japan, loading on feeder ship in Shiogama port (a regional port in northern Japan), transferring to trunk line in Tokyo port, and finally exporting to Canada, it will be recorded as the export of Miyagi prefecture, and handled by Tokyo port, but not regional ports (i.e., Shiogama port), because the customs clearance was proceeded at Tokyo port. Alternatively, in the case that this cargo was loaded

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[13] In general, it is difficult to estimate the accurate container shipping freight rates (tariff) between two points of ports because container transport is a kind of global transportation with each port as a node; most of the transportations by shipping companies (more than 80% of cargo on major routes) are based on a yearly contract with large shippers individually. Therefore, the actual shipping tariff is not open to the public because it is a top secret between shippers and shipping companies (Source: the interviews for Japan Federation of Costal Shipping Associations and the Busan Port Authority). Alternatively, some organizations publish the aggregated container freight indexes on main routes for reference; for example, *Containerisation International*. However, the tariff index from these organizations is just the aggregated ones on main routes; like Asia-Northern America route and Asia-Europe route, not on ports-pair. On the other hand, small shippers (less than 20% of cargo on major routes) will have a contract with forwarders (not shipping company directly) because of the bargaining power for (relatively big) shipping company. However, the contract price with forwarders includes not only shipping freight but also port handling and terminal handling charges, in addition to inland transport costs and warehouse costs (Source: the interviews for Japan Federation of Costal Shipping Associations and the Busan Port Authority (BPA)). In the US, firm import transaction-level shipment charges are available in the US Census: Imports of Merchandise (see applications in Hummels et al., 2009); however, firm-level shipment charges (maritime shipping) are not available in Japan.

[14] Although micro-level container freight rate data are not available in Japan, price advantage in Busan port could be partially observed. The transshipment at Busan has advantages against Japan's major ports (Source: interview with Japanese forwarders). For example, the estimated shipping tariff from Busan to Los Angeles is 1,330 USD per TEU, and that from Yokohama to Los Angeles is 2,160 USD in 2010 (Data source: Drewry Shipping Consultants Ltd., 2010b).

[15] Includes only the international maritime trade volumes that are handled by containers.

on feeder ship in Shiogama port but transferred to trunk line in Busan port, then this cargo will be recorded as the export of Miyagi prefecture and handled by the regional ports, based on the place proceeding customs clearance.

Since we have the major port-level container traffic data for each prefecture, we may calculate the container handling share of each port for a specific prefecture and year. The merit of the share data over the data of absolute value (container traffic) is that any disturbance from the variations on prefecture-year level trading volumes can be eliminated. We consider only the market share of each port in a prefecture's container traffic (i.e., five major ports and the aggregation of regional ports).

The survey period covered in CCFS is just one month, October 1st to 31st, in each year. It is thus necessary to check whether it is qualified to be the proxy of annual data when calculating the port-specific container handling share. By aggregating the prefecture-port level monthly data of CCFS to port-level monthly data, and calculating the share of each port in the national monthly total container traffic, we find the correlation between the handling share of monthly data (source: CCFS; measured by tonnage volumes) and annual data (source: Japan Port Statistics Yearbook, various years; measured by TEUs) is quite high (Table 2). The correlation ranges from 0.93 to 0.99 (see a detailed explanation in the notes of Table 2), suggesting the monthly export/import data are qualified as proxies of annual data.

Another issue to proceed with the empirical analysis is to identify the expected container traffic diversion to Busan port. Data for Japan's container traffic handled by Busan port are not available; however, we may partly observe the related volumes based on CCFS. Table 3 shows that the container shipping routes in Japan are systematically different for the major ports and regional ports. Approximately 80% of the container traffic are directly shipped between the major ports of Japan and the international origins/destinations, while for the regional ports, approximately 80% of the container traffic are transshipped in Busan port, rather than direct shipping. For the Middle East, India, and Africa, this pattern is somewhat weak, but the trade volumes with these regions account only for 17.2% in Japan's total trade volume. This implies the container traffic handled by Japan's regional ports, as recorded in CCFS, are largely transferred to Busan port; the container traffic handled in regional ports is thus a qualified proxy of Japan's container traffic handled by Busan port.[16] To examine the expected diversion mechanism of port choice, as proposed in Section 4.1, we need to test whether the container handling share of Keihin port area decreased and the relative share of regional ports (i.e., Busan port) increased in treatment group, responding to the Hanshin earthquake, or the exogenous shock on Busan port's transport density.

5 Findings

5.1 Descriptive evidence

Before proceeding with the econometrical analysis, we present sufficient descriptive evidence to support that the research design as proposed in Section 4.1 is logical.

First, the distance to Keihin port area is heterogenous for the prefectures in northern Japan, which is a necessary condition to identify the heterogeneity on the impacts of exogenous shock (as in the Figure 2 (c)). 18 prefectures located in northern Japan are included in our analysis, and their distances to Keihin port area for them range between 10 kms and 1000 kms (Figures 3 and A.2). Prefectures close to Keihin port area (less than 250 kms to Tokyo port, i.e., Group 1 in Figure 3)[17] are set as the control group, and the remaining prefectures (i.e., Group 2 in Figure 3, more than 250 kms to Tokyo port) constitute the treatment group, which are relatively far away from Keihin port area. Specifically, Group 1 includes 11 prefectures (Tokyo, Chiba, Kanagawa, Saitama, Yamanashi, Nagano, Shizuoka, Fukushima, Ibaraki, Tochigi, and Gunma) and Group 2 includes seven prefectures (Hokkaido, Aomori, Akita, Yamagata, Niigata, Iwate, and Miyagi). As predicted in the model, Groups 1 and 2 may respond differently to the expansion of Busan port. Group 2, but not Group 1, tends to be affected by the Busan port expansion caused by the exogenous shock.[18]

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[16] Two regional ports are also placed as international ports: Kitakyushu and Hakata, with greater scale than the general regional ports; that is, these two ports have a few of direct shipping routes to a part of the international destinations. However, these two ports are located in southern Japan; in northern Japan, the scale of all the regional ports is small. Therefore, we suppose the high transshipment share in Busan port (i.e., around 80%) applies for northern Japan regional ports. Our strategy to use the container traffic handled in northern Japan's regional ports as the proxy of northern Japan's container traffic handled by Busan port is acceptable.

[17] The cutoff distance (250 kms) is set based on the geographical scope of Kanto great metropolitan area (including Tokyo, Chiba, Kanagawa, Saitama, Ibaraki, Tochigi, and Gunma). Nagano, Shizuoka, Fukushima, and Yamanashi are also included in Group 1 because they are also located within 250 kms from Tokyo port.

[18] One additional reason for the prefectures close to Tokyo (i.e., Group 1) to be the stable hinterland of Keihin port area is the availability of road transportation. It is economical for local shippers to use road transportation between their locations to Keihin port area (Source: Regional Cargo Movements Survey, by MLIT). Although the unit price for road freight is much higher than maritime transportation, road transport is preferred in short-distance freight because of its time efficiency. For Group 1, if the shippers there divert the shipments to other two port areas, i.e., Hanshin and Busan, they have to use maritime shipping to reach the hub, since road transportation is either not available or costly due to remoteness. Busan port area thus suffers from a distance disadvantage to compete

Second, the main hinterlands of Keihin and Hanshin port areas are not overlapped. Consequently, the Hanshin earthquake did not directly affect the container shipping activities in northern Japan. For these 18 prefectures, on average, more than 80% of the container cargoes (both imports and exports) were handled by Keihin port area before the earthquake (Figure 4); they scarcely used Hanshin port area. On average, the container handling share of northern Japan that was handled by Hanshin port area in 1993 was less than 5% (Data source: computed based on CCFS; see also in Figure A.1).[19] By contrast, for the remaining 29 prefectures (Japan consists of 47 prefectures), Hanshin port area was the largest gateway for most of them; they scarcely used Keihin port area (on average, less than 2% in the container volume share in 1993; data source: computed based on CCFS, see also in Figure A.1). The hinterland boundary of the two port areas is naturally set based on the geographical proximity. Therefore, we may suppose the port choice in northern Japan was not directly affected by the Hanshin earthquake. The expected post-Hanshin earthquake container cargo diversion in Group 2, if any, stems from the economies of transport density in Busan port.

Then, Figure 4 shows that the trend of Group 1 and Group 2 on the container handling share of Keihin port area after the 1995 earthquake satisfies the model predictions. Before the Hanshin earthquake, both the groups are dominated by the Keihin port area in both exports and imports; the average handling share is higher than 80% in all the three time waves (1985, 1988, and 1993). Although the share of Group 2 for 1985–1988 decreased significantly, this is solely affected by Hokkaido prefecture; by excluding Hokkaido, this trend largely disappears (Figure 4). However, after the earthquake, we find in 1998 and 2003, the container handling share of Keihin port area largely decreased for Group 2 while it insignificantly changed for Group 1. When we depict the disaggregated plot for these prefectures against their distance to Keihin port area, Figure 5 shows for 1993, the dominance of Keihin port area in Groups 1 and 2 is not so much correlated with the prefecture's distance to Keihin port area; however, in 2003, prefectures close to Keihin port area almost stabilized in the container handling share of Keihin port area, while for prefectures in Group 2,

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with Keihin port area for the shippers in Group 1. However, for the prefectures in Group 2, they are relatively far away from Tokyo (250–1000 kms in geographical distance); thus, they partially use maritime transportation for domestic logistics between their locations to Keihin port area, since the road freight cost is much higher in unit costs than maritime shipping, and thus not preferred in medium- and long-haul freight.

[19] Precisely, in 1993, 83.7% of exports and 88.4% of imports in Groups 1 and 2 were handled by Keihin port area, while for the remaining prefectures of Japan, this share was only 1.9% and 1.0% respectively (Data source: CCFS), implying that northern Japan is the only, but stable, hinterland of Keihin port area in Japan. Hanshin port area is the largest international container gateway of southern Japan, followed by the Nagoya port, and Busan port via Japanese regional ports.

they mostly dropped, with more remote prefectures' share declining more significantly.

Table 4 presents the container handling share of Group 2 by ports in 1993 and 2003. In 1993, 81.0% of exports and 81.6% of imports in Group 2 are handled by Keihin port area; moreover, 9.7% of exports and 15.7% of imports are handled by regional ports. However, the share of Keihin port area largely declined in 2003. The lost market share is largely diverted to regional ports, which increased to 51.8% for exports and 68.9% for imports. The aggregated share of Hanshin port area and Nagoya port is minor for Group 2 (also, for Group 1, related statistics are available upon request) in both periods before and after the earthquake. Therefore, to observe the expected port choice diversion, we need to only test whether the container handling share of Keihin port area in Group 2 decreased due to the exogenous shock at Busan port by the earthquake, which is equivalent to an increase in the market share of regional ports (i.e., the transshipment cargoes at Busan port) in Group 2.

5.2 Econometrical specifications

Keihin port area accounts for high container handling share of both Group 1 and Group 2 before 1995, and the container shipping of Group 2, but not Group 1, is expected to be affected by the transport density economies at Busan port from the earthquake, it is thus straightforward to conduct a difference-in-difference (DID) estimation by comparing the pre- and post-earthquake scenario, and Group 1 and Group 2 on the container shipping market share of Keihin port area.

We conduct regressions by identifying the year-prefecture-port container traffic change responding to the event shock in northern Japan (Group1 and Group 2). The dependent variable is set as the prefecture-year level container handling share of Keihin port area (take the export as an example): $Share_{it} = Volume_{it} / VOLUME_{it}$. $Volume_{it}$ is the export container volume of prefecture i in year t that is handled by Keihin port area, and $VOLUME_{it}$ is the total export container volume of prefecture i in year t. The relative share of import is calculated analogously. By testing the treatment effects on the port choice diversion with share data (i.e., *Share*) rather than absolute volume of container traffic (i.e., *Volume*), we may eliminate the disturbances from prefecture-year level fluctuations of trade performance and container traffic to the baseline estimations.

As shown in equation R.1, *Postquake* is a dummy equal to one for the years after the Hanshin earthquake (1998, 2003, 2008, and 2013), and zero for 1985, 1988, and 1993. *G2* is a dummy equal to 1 for Group 2 and 0 for Group 1. By taking Group 1 as the control group, we may eliminate the impacts of the national trend of regional port expansion, as well as other unobservable factors affecting container shipping industry in northern Japan, on the container shipping activities of Group 2. By interacting *Postquake* and *G2*, α , the DID term, thus captures the concerned treatment effect. δ and μ capture the prefecture and year fixed effects, respectively; ε is the error term (Data summary is shown in Table A.2):

(R.1) $$Share_{it} = \alpha Postquake_t \times G2_i + \delta_i + \mu_t + \varepsilon_{it}.$$

The regression consists of 126 observations for export and import, respectively (18 prefectures and 7 time waves). Furthermore, to control for the pre-1995 trend, we estimate the year-by-year difference with equation R.2:

(R.2) $$Share_{it} = \sum_{t=1}^{6} \beta_t Year_t \times G2_i + \delta_i + \mu_t + \varepsilon_{it}.$$

Year is a year dummy for six years respectively (1988, 1993, 1998, 2003, 2008, 2013; 1985 is set as the reference year). Other variables are identical with that in equation R.1.

In equations R.1 and R.2, the treatment group is identified by a dummy variable (*G2*), that is, whether a prefecture is within 250 kms to Keihin port area or not. Nevertheless, we need to test whether the setting of boundary matters to the results, which leads to potential bias to the impact evaluation. We thus use a continuous variable (physical distance to Tokyo port) to identify the proximity to Keihin port area. Equation R.3 is the estimate considering the distance to Keihin port area. $\ln(Dist_i)$ in equation R.3 is the logarithm of prefecture *i*'s distance to Tokyo port. Other variables are identical with that in R.2:

(R.3) $$Share_{it} = \sum_{t=1}^{6} \gamma_t Year_t \times \ln(Dist_i) + \delta_i + \mu_t + \varepsilon_{it}.$$

5.3 Baseline results

Table 5 presents the estimations of equations R.1–R.3. In columns 1–2 (estimation of equation

R.1), we find after the earthquake, the container handling share of Keihin port area in Group 2 significantly declined, by 26.6% and 45.3% in exports and imports, respectively, compared with that in Group 1. In columns 3–4 (estimation of equation R.2), we have consistent results with the estimates of equation R.1, a significant drop on the container handling share of Keihin port area in Group 2 is observed since 1998 (post-Hanshin earthquake) but not in 1988 and 1993. This suggests the decrease of related Keihin port area container handling share in Group 2 was not due to a pre-quake trend.[20]

Table 6 shows the between-year difference based on the estimates of columns 3–4 of Table 5. We find the major decrease of container handling share of Keihin port area occurred in 1993–2003, the period when Kobe was destroyed and the new port hierarchy was under reconstruction. Before the earthquake (1985–1993) and after the reshaping of transport network that the port hierarchy moves to a new steady status (2003–2013), we do not find significant difference between the two groups, and between the periods (1985–1993, 2003–2013). We may expect the diversion on port choice from Keihin port area to Busan port via Japanese regional ports exists only in the periods shortly after the earthquake (1995–2003). Based on the estimates of Table 6, the relative share of exports and imports declined by 31.2% and 47.2% in 1993–2003. This is interpreted as the exogenous expansion of Busan port's transport density by Hanshin earthquake leads to a spatial reorganization of northern Japan's container traffic. Keihin port area lost a part of its hinterlands in northern Japan.

Although northern Japan is dominated by Keihin port area and regional ports, a small part of the container cargoes are handled by other major ports (i.e., Kobe, Osaka and Nagoya) (as shown in Table 4), we thus replace the *Share* as the aggregated container handling share of five major ports instead of the share of Keihin port area. Then the estimated diversion effects purely stem from the traffic diversion to regional ports. Related estimations are shown in columns 5–6 of Table 5, results are essentially unchanged. Then, to avoid the bias from the dummy variable setting of treatment group, we estimate equation R.3 and the results are shown in columns 7–8 of Table 5, consistently, we find the distance effects are significant from 1998.

Therefore, we find the container handling share of Keihin port area in Group 2 declined by 31.2

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[20] To relieve the limitations of the present results arising from the small sample size, we present the confidence intervals using bootstrapped standard errors (100 and 500 bootstrap repetitions) (Figure A.3). Results are essentially consistent with the baseline estimates in columns 3–4 of Table 5.

and 47.2 percentage points for export and import respectively between 1993 and 2003 (Table 6); the lost market share of Keihin port area was largely diverted to the regional ports. Given that around 80% of the container trade cargoes of Japan's regional ports are transshipped in Busan port (Table 3), we can draw a conclusion that, for Group 2 in northern Japan, the container cargoes were diverted from Keihin port area to Busan port via Japanese regional ports. We conclude this is due to the economies of transport density in Busan port, which is caused by the diversion of Kobe port users to Busan port from the Hanshin earthquake.

5.4 Omitted variables and additional concerns

We are still concerned about the bias of baseline estimations from omitted variables. First, we need to confirm whether the port choice change of container shippers in Group 2 is due to the development of regional ports in Group 2. Our results tend to be biased if the regional ports in Group 2 showed better development than those of Group 1 after 1993. For the regional ports in both Groups 1 and 2, all of them have been developed in the 1960s or earlier (Sources: Various, collected by the authors), though the trade container traffic did not significantly expand before 1995.[21] Furthermore, there were no significant policy changes or large-scale investment regarding the regional ports of northern Japan. Therefore, this does not seem to be a valid explanation of the post-Hanshin earthquake port choice diversion in Group 2, which was not observed in Group 1.

Second, we are concerned about the issues arising from the direction imbalance in transportation. Among the literature discussing the impact of endogenous transport costs on economic geography, one additional channel, except the economies of transport density, is the directional imbalance (e.g., Behrens and Picard, 2011; Jonkeren et al., 2011; Takahashi, 2011; Tanaka and Tsubota, 2016), which suggests the positive relation between directional imbalance and transport costs. For example, the container freight index from Shanghai to Los Angeles, or eastbound, is 1,330 USD per TEU in January 2016; however, the index from Los Angeles to Shanghai, or westbound, is 600 USD per TEU only because of less demand (Drewry Shipping Consultants Ltd., 2016). High transport density in one direction will lead to an opportunity cost of returning empty,

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[21] In this context, the container traffic refers to the trade cargoes (i.e., export and import) only, as recorded in CCFS, and does not include the cargoes loaded in regional ports and transferred in Japan's domestic major ports. For the latter, it is recorded as container cargoes handled by the major ports.

thus increasing the freight rates charged to shippers located in regions that are net exporters. It is therefore theoretically ambiguous what the net effect is of a change in the trade volume on trade costs, as it depends on what type of effect dominates, density economies (encourage agglomeration) or directional imbalance (encourage dispersion) (Jonkeren et al., 2011).

Since the directional imbalance also affects the unit shipping costs in Busan port, they tend to be the omitted variables of current estimations. Unfortunately, data for measuring the directional imbalance of container cargoes in Busan port are not available. Alternatively, we present the empty container share incidence by region to show that the condition of directional imbalance in container shipping is stable in 1980–2009 (Table A.3). There was no significant and persistent global change on the empty container incidence during the period 1980–2009 (relative share stabilizes at around 21.0%). The disaggregate regional-level data were slightly fluctuating, however, basically stable (Table A.3). Therefore, the diversions on port choice, as observed in the current study, tend to be affected by the channel of density economies, rather than directional imbalance, in container transportation.

Moreover, we are concerned whether the expansion of Busan port in 1995 was caused by the national trade expansion of South Korea, rather than the Hanshin earthquake. By examining the trade growth of South Korea for a long period (1985–2011), we find the annual trade volume growth (in USD) was 11.0% in 1984–1994 and 10.9% in 1995–2011 (WTO, 2016). In both periods before and after 1995, the trade growth rate did not change significantly. Therefore, the *leap-style growth* of Busan port in 1995 is expected to mainly stem from the container traffic diversions of Kobe port, as shown in Figure 1 (a) and (c).

In addition, during the study period, there was no significant market-oriented reform in both Japan and South Korea. Therefore, we can ensure the institutional features are essentially unchanged and the related omitted variables do not impact the causal inference of the current analysis.

5.5 A preliminary extension: trade volumes and manufacturing structure

A decrease in container transportation costs actually reflects an increase in productivity that affects industries producing heavy goods more than those producing light goods.[22] This implies that

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[22] For maritime shipping (not only container shipping), the tariff of heavy goods will be measured by weight volume, while cubic

the port choice diversion of shippers in Group 2 of northern Japan may alter the patterns of its comparative advantage and lead to greater specialization in the production and trade of heavier goods (see a more detailed discussion in Duranton et al. (2014): Comparative Static 6 and related empirical tests (pp. 696 & 713–716)). Moreover, Ducruet and Itoh (2016) find port throughput specialization largely reflects local economic specialization. A structural change in manufacturing production and trade pattern is thus expected.

Figure 6 confirms this hypothesis. By plotting the time trend of total container tonnage volume by region, we find Group 2 experienced a much higher growth since 1998 than Group 1, while the growth pattern is quite similar for Group 1 and Group 2 for the earlier years (i.e., 1985–1998). We also exclude the Tokyo metropolitan area (MA) (Tokyo, Kanagawa, Saitama, and Chiba) from Group 1, since Tokyo MA is the most important industrial area of Japan; therefore, the container trade volumes and growth pattern are not comparable with the peripheral regions. The trend does not essentially change, as shown in Figure 6. By replacing the dependent variable as the prefecture-year level container cargo traffic (the absolute tonnage volume), we estimate equation R.1. Results shown in Table 7 are consistent with Figure 6. Column 1 implies Group 2 (excluding Tokyo MA) has 61.0% higher growth in container export traffic than Group 1 after the Hanshin earthquake; column 2 presents the results for imports, the related impact is estimated at 57.5 percentage points. Results are unchanged by including four prefectures in Tokyo MA into regressions (columns 3–4 of Table 7).

One concern that needs to be clarified is the expansion of container export/import tonnage volume in Group 2 began from the period 1998–2003, rather than 1993–1998 (Figure 6), while the diversions of shippers' port choice in Group 2 began earlier, in 1993–1998 on the estimated results. This rejects the assumption that, rapid trade growth in Group 2 allows for rapid development of its regional ports, and thus, the container handling volume of regional ports grows more rapidly in Group 2 than in Group 1 (i.e., the baseline results in Table 5).

However, the trade growth on total container weight volume of Group 2 may stem from an increase on weight-to-value share, or an increase on trade values. For the latter, it may be caused by other factors, rather than the mechanism proposed by Duranton et al., 2014. For example, manufacturing products of Group 2 become popular in overseas markets during the post-Hanshin

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volume is suitable for light goods. Due to the limitations on data (data in CCFS are measured in weight volume, and not in cubic volume), we focus only on the weight volume of container cargoes.

earthquake period. Since the data of weight-to-value share, as well as value, of the trading container cargoes are not available, we conduct alternative tests using the data of prefectures' manufacturing sector.

As Japan is a country with limited natural resources, its manufacturing sector is highly dependent on importing (foreign) intermediate goods as inputs. Furthermore, the manufacturing products are largely exported to foreign markets based on its comparative advantage. The total manufacturing input and output values are thus supposed to be qualified proxies of container trade values. We estimate the impacts of Hanshin earthquake on the prefecture-year level manufacturing input and output values, and manufacturing earnings per capita of Group 2, based on equation R.4:

(R.4) $$\ln(values)_{it} = \sum_{t=1}^{4} \psi_t Period_t \times G2_i + \delta_i + \mu_t + \varepsilon_{it} \,.$$

In this equation, *values* refer to the prefecture-year level *Value of manufactured goods shipment*, *Value of raw materials used in manufacturing*, and *Manufacturing earnings per capita* in various specifications (categories). $Period_t$ $(t = 1-4)$ is a dummy variable identifying the periods of 1990–1994, 1995–1999, 2000–2003, and 2008–2013, and the period of 1985–1989 is set as the reference period (We have the annual data of *values* during the periods of 1985–2003 & 2008–2013; see the data summary in Table A.4). Other variables are identical with that of equation R.2.

Related estimations of equation R.4 are shown in Table 8. We find no significant evidence in the impacts of Hanshin earthquake and Busan port expansion on the value terms of manufacturing in Group 2, which is different from the results measured by tonnage volume of container traffic. This result is consistent with Duranton et al. (2014), who find more highways will lead to the cities in the US specializing in sectors producing heavy goods, despite the insignificant effect of highways on the total value of exports. With better accessibility to international markets, Group 2 may specialize in manufacturing sectors producing heavy goods but low value/weight rate. However, detailed investigations on the port diversion effect on manufacturing locations are beyond the scope of this study and will be considered in future research.

6 Concluding remarks

Taking the Hanshin earthquake as an exogenous windfall to the container shipping demands of Busan port, this study finds that the economies of transport density in Busan port lead to an expansion of Busan's hinterlands in northern Japan. A diversion of container cargo traffic from Keihin port area to Busan port is observed for the shippers in northern Japan. Due to the expansion of Busan port, the market share of Keihin port area in the container transportation of related regions declined by about 40 percentage points. We also find that the unintended port diversion effects on container shipping lead to a structural change in manufacturing and trade pattern in the related regions. The current study demonstrates the nonnegligible impacts of transport density on the spatial structure of transport network.

6.1 Implications to the evolution of port hierarchy

A recent relevance of this study is the impacts of the bankruptcy of *Hanjin Shipping* (South Korea) (August, 2016). As South Korea's largest and one of the world's top ten container carriers, the bankruptcy of *Hanjin Shipping* imposed a negative shock on the container shipping industry of South Korea, in particular, Busan. South Korean ports have been rapidly losing their share in the international transshipment market after this event. For example, the tranship cargo at South Korean ports from Japan's regional ports to the US in September 2016 had decreased by 33.4% compared to that in September 2015; in addition, the related volume from China to the US decreased by 17.2%, from Vietnam to the US decreased by 14.4%, and so on (Logistics Today, 2016). The current study implies that the bankruptcy of *Hanjin shipping* may have led to a reorganization of the port hierarchy in northeastern Asia, rather than South Korea only. Since the operation of a leading hub port is important to the local economic development, various negative economic consequences (e.g., consumer price inflation; lead-time increase) of the bankruptcy of *Hanjin Shipping* on South Korea are thus expected.[23]

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[23] This is the case for Hanshin earthquake. Before the earthquake, the Japanese major ports were centrally located between eastern Asia (e.g. Hong Kong) and the west coast of US (e.g. Los Angeles) on the trans-Pacific truck routes. However, after 1995, because of the lagged development at Kobe port, the trunk routes omitted Japanese major ports after the ship calls at Busan port; the Japanese ports partly became the feeder ports of Busan port' network. This caused logistics cost appreciation and lead-time increasing in Japan's manufacturing and trade industry. MLIT estimated the impacts of port hierarchy transition (from Kobe-dominated to Busan-dominated) in the period of 1997–2002: the Japanese price of imported goods increased (2.3% for foods, 3.7% for textiles, and 1.2% for general

6.2 Limitations of the present study

An obvious shortcoming of the present study is the lack of container transportation costs data for Busan port. We do not know how exactly the container transportation costs via Busan change after the Hanshin earthquake. Therefore, the magnitude of impacts of density economies cannot be estimated. In addition, the current study still cannot fully explain the polarized port hierarchy in northeastern Asia. Although the port diversions of Group 2 contribute to the decline of Keihin port area's relative scale (as shown in Figure 1 (d)),[24] it is also related to other factors. For example, the rate of trade growth in South Korea is much higher than Japan in the study periods (Annual trade growth rate is 3.8% for Japan and 10.9% for South Korea in 1994–2011 (in USD value terms)) (WTO, 2016). This will cause the unproportional growth of Busan port compared with Hanshin and Keihin port areas of Japan.[25] Also, the potential diversions of international transshipment cargoes from Keihin port area to Busan port is not counted in the current study due to data limitations.

References

Behrens, K., C. Gaigné, G.I.P. Ottaviano, and J.-F. Thisse (2006) How density economies in international transportation link the internal geography of trading partners, *Journal of Urban Economics*, 60: 248–263.

Behrens, K. and P.M. Picard (2011) Transportation, freight rates, and economic geography, *Journal of International Economics*, 85: 280–291.

Bleakley, H. and J. Lin (2012) Portage and path dependence, *Quarterly Journal of Economics*, 127: 587–644.

Bosker, M., S. Brakman, H. Garretsen, and M. Schramm (2007) Looking for multiple equilibria when geography matters: German city growth and the WWII shock, *Journal of Urban Economics*, 61: 152–169.

Braeutigam, R.R., A.F. Daughety, and M.A. Turnquist (1982) The estimation of a hybrid cost

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machineries), and Japan's export volume decreased (4 billion USD a year) (Maritime Bureau of MLIT, 2005).

[24] Based on the port diversion effects of Hanshin earthquake, as estimated in Table 6, the container traffic volumes in Keihin port area would have increased by 4.0% on exports and 6.7% on imports in 2003 if the Hanshin earthquake did not occur (computed based on the coefficients of Table 6 and CCFS).

[25] Also, the shrank of Hanshin port area was caused by both the container cargo diversion to Busan port and the lagged redevelopment of Hanshin industrial area. As the second largest manufacturing area of Japan, Hanshin industrial area was seriously damaged in Hanshin earthquake; as a result, the local container shipping demands decreased, contributing to the decrease of container traffic in Hanshin port area. Precisely, Keihin industrial area (Tokyo, Kanagawa, Chiba, and Saitama) and Hanshin industrial area (Osaka and Hyogo) are highly comparable with respect to the container trade volume growth in 1985–1993. For Keihin industrial area, annual export and import growth are -0.8% and 9.0%, respectively, in this period; for Hanshin industrial area, the figures are -0.6% and 10.4%. However, for the period of 1993–2013, the related figures are 5.4% and 9.3% for Keihin area and 2.7% and 6.0% for Hanshin area. Thus, the Hanshin industrial area has lagged in industrial redevelopment after the 1995 earthquake (Data source: computed based on CCFS).

function for a railroad firm, *The Review of Economics and Statistics*, 64: 394–404.

Brueckner, J.K., N.J. Dyer, and P.T. Spiller (1992) Fare determination in airline hub-and-spokes networks, *The RAND Journal of Economics*, 23: 309–333.

Busan Port Authority (2011) Port of Busan Container Statistics 2010. Busan: Busan Port Authority.

Caves, D.W., L.R. Christensen, and M.W. Tretheway (1984) Economies of density versus economies of scale: why trunk and local services airline differ, *The RAND Journal of Economics*, 15: 471–489.

Chang, S.E. (2000) Disasters and transport systems: loss, recovery, and competition at the Port of Kobe after the 1995 earthquake, *Journal of Transport Geography*, 8: 53–65.

Chang, S.E. (2010) Urban disaster recovery: a measurement framework and its application to the 1995 Kobe earthquake, *Disaster*, 34: 303–327.

Containerisation International (1997) Japan's main ports head for 10 million annual TEU barrier. August, 31st.

Davis, D.R. and D.E. Weinstein (2001) Bones, bombs, and break points: the geography of economic activity, *American Economic Review*, 92: 1269–1289.

Davis, D.R. and D.E. Weinstein (2008) A search for multiple equilibria in urban industrial structure, *Journal of Regional Science*, 48: 29–65.

Drewry Shipping Consultants Ltd. (2010a) Container Market Annual Review and Forecast 2010/2011. Retrieved: http://www.drewry.co.uk/publications

Drewry Shipping Consultants Ltd. (2010b) Container Freight Rate Insight 2010. Retrieved: https://www.drewrycfri.co.uk/subscription_packages

Drewry Shipping Consultants Ltd. (2012) Container Market Annual Review and Forecast 2012/2013. Retrieved: http://commons.wmu.se/lib_reports/1

Drewry Shipping Consultants Ltd. (2016) Container Freight Rate Insight 2016. Retrieved: https://www.drewrycfri.co.uk/subscription_packages

Ducruet, C. and H. Itoh (2016) Regions and material flows: investigating the regional branching and industry relatedness of port traffics in a global perspective, *Journal of Economic Geography*, 16: 805–830.

Duranton, G., P.M. Morrow, and M.A. Turner (2014) Roads and trade: evidence from the US, *Review of Economic Studies*, 81: 681–724.

Fossey, J. (1997) Boxes galore. Containerisation International, January, 71.

Fujita, M., P. Krugman, and A.J. Venables (1999) *The Spatial Economy: Cities, Regions and International Trade*. MIT Press, Cambridge, MA.

Guerrero, D. and H. Itoh (2016) Ports, regions and manufacturing systems: the case of Japan, *Case Studies on Transport Policy*, forthcoming.

Harada, M. (1996) The content of leadership competition between hub-ports in Asia (in Japanese), *SRIC-MOOK RD*, Mitsubishi UFJ Research and Consulting, 001 (July): 108–117.

Hummels, D., V. Lugovskyy, and A. Skiba (2009) The trade reducing effects of market power in international shipping, *Journal of Development Economics*, 89: 84–97.

Itoh, H. (2013) Market area analysis of ports in Japan. The IAME 2013 annual conference, Marseille, France pp.1–21 (hal–00918672).

Japan Port Statistics Yearbook (various years) Tokyo: Ministry of Land, Infrastructure, Transportation and Tourism (MLIT).

Jonkeren, O., E. Demirel, J. van Ommeren, and P. Rietveld (2011) Endogenous transport prices and trade imbalances, *Journal of Economic Geography*, 11: 509–527.

Kobe City FIRE Bureau (2006) Situation of damage and victims: Hanshin-Awaji earthquake (in Japanese). Retrieved: May 25th, 2008.

Logistics Today (2016) http://www.logi-today.com/259476 (in Japanese): Oct. 14th, 2016. Retrieved: Oct. 17th, 2016.

Maritime Bureau of MLIT (2005) The role-sharing of Japanese regional ports and the differences between Japanese major ports and regional ports (in Japanese): documents for special committee.

Mori, T. and K. Nishikimi (2002) Economies of transport density and industrial agglomeration, *Regional Science and Urban Economics*, 32: 167–200.

Mori, T. (2012) Increasing returns in transportation and the formation of hubs, *Journal of Economic Geography*, 12: 877–897.

Ocean Commerce Ltd. (2013) International Transportation Handbook 2013 (in Japanese). Tokyo: Ocean Commerce Ltd. Retrieved: www.ocean-commerce.co.jp

Port Report of Japan (2012) Tokyo: Ministry of Land, Infrastructure, Transportation and Tourism (MLIT).

Redding, S.J., D.M. Sturm, and N. Wolf (2011) History and industry location: evidence from German airport, *The Review of Economics and Statistics*, 93: 814–831.

Shipping Gazette (1997) Shipping Gazette (in Japanese). Tokyo: The Japan Press Ltd. (September 22nd, 1997).

Takahashi, T. (2011) Directional imbalance in transport prices and economic geography, *Journal of Urban Economics*, 69: 92–102.

Tanaka, K. and K. Tsubota (2016) Directional imbalance in freight rates: evidence from Japanese inter-prefectural data, *Journal of Economic Geography*, forthcoming.

WTO (2016) Merchandise trade indices: time series on international trade. Retrieved: http://stat.wto.org/Home/WSDBHome.aspx?Language=E

Xu, K., R. Windle, C. Grimm, and T. Corsi (1994) Re-evaluating returns to scale in transportation, *Journal of Transport Economics and Policy*, 28: 275–286.

Tables

Table 1: The number of international trunk routes in selected northeastern Asian ports

	Busan	Keihin port area (Tokyo & Yokohama)	Nagoya	Hanshin port area (Kobe & Osaka)
Europe	5	2	2	2
Mediterranean Sea	9	1	0	1
North America	43	30	9	12
South America	13	2	0	0
Australia	6	4	0	4
Middle East & India	9	1	1	1
Africa	1	0	0	0
Southeast Asia	115	70	38	57
China	136	71	32	63
Japan	89	-	-	-
South Korea	-	23	15	15

Notes: Data refer to the year 2012. Data source: Ocean Commerce Ltd. (2013).

Table 2: The correlation of annual and monthly port-level container traffic data

Year	1985	1988	1993	1998	2003	2008	2013	Total
Export	0.9910	0.9637	0.9673	0.9572	0.9264	0.9291	0.9706	0.9617
Import	0.9830	0.9944	0.9899	0.9464	0.9403	0.9715	0.9934	0.9759

Notes: The correlation between the monthly and annual data for the container handling share of major ports in the national container volume. Precisely, the correlation of $volume_{it}/volume_t$ for annual and monthly data; i: port; t: year. $volume_{it}$: container volume of port i in year t; $volume_t$: national container volume in year t. Export and import data are presented separately. Data source: Japan Port Statistics Yearbook (various years) and CCFS.

Table 3: Japan's international container cargoes and their shipping routes

	North America		Europe		South America	
	Major ports	Regional ports	Major ports	Regional ports	Major ports	Regional ports
Direct	80.5	n.a.	96.7	n.a.	66.4	< 4.0
Trans. at Busan	2.7	81.9	1.7	71.3	5.4	78.3
Trans. at others	16.8	n.a.	1.6	n.a.	28.2	n.a.

	Australia		Middle East & India		Africa	
	Major ports	Regional ports	Major ports	Regional ports	Major ports	Regional ports
Direct	82.8	< 4.0	30.8	n.a.	33.2	< 3.0
Trans. at Busan	3.0	88.9	16.9	62.6	< 3.0	65.8
Trans. at others	14.2	n.a.	52.3	n.a.	n.a.	n.a.

Notes: Data are based on the container traffic in November, 2008; The data are in percentage point units; *Direct*: direct shipping between Japan and international origins/destinations; *Trans. at Busan*: transship at Busan port; *Trans. at others*: transship at other Asian ports: Singapore, Hong Kong, Shanghai, Kaohsiung, and so on. Data regarding shipping routes between Japan and east Asian countries are not available. Data source: Ports and Harbors Bureau, MLIT, Japan.

Table 4: The port-specific container traffic share of Group 2

		Keihin port area	Hanshin port area	Nagoya port	Regional ports
Export	Share$_{1993}$	81.0%	7.7%	1.6%	9.7%
	Share$_{2003}$	45.4%	2.2%	0.7%	51.8%
	Share$_{2003}$–Share$_{1993}$	-35.6%	-5.5%	-0.9%	42.1%
Import	Share$_{1993}$	81.6%	2.6%	0.1%	15.7%
	Share$_{2003}$	29.5%	0.9%	0.7%	68.9%
	Share$_{2003}$–Share$_{1993}$	-52.1%	-1.7%	0.6%	53.2%

Notes: $Share_{jt} = (\sum_{i=1}^{7}(volume_{ijt}/\sum_{j=1}^{4} volume_{ijt}))/7$, i =1–7 refers to seven prefectures in Group 2, j =1–4 refers to Keihin port area, Hanshin port area, Nagoya port, and the unclassified regional ports, t =1993, 2003 refers to two time points; $volume_{ijt}$ is the container traffic (measured by TEUs) of prefecture i handled by port area j in year t. Data source: Computed based on CCFS.

Table 5: Baseline estimations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Dependent variable: Container handling share							
	Keihin Export	Keihin Import	Keihin Export	Keihin Import	Big 5 Export	Big 5 Import	Keihin Export	Keihin Import
G2×*Postquake*	-0.266*	-0.453*						
	(0.035)	(0.026)						
G2×*y1988*			-0.089	-0.098	-0.108	-0.091		
			(0.068)	(0.075)	(0.069)	(0.080)		
G2×*y1993*			-0.049	-0.093	-0.060	-0.100		
			(0.056)	(0.084)	(0.055)	(0.081)		
G2×*y1998*			-0.221*	-0.386*	-0.279*	-0.413*		
			(0.071)	(0.085)	(0.073)	(0.085)		
G2×*y2003*			-0.360*	-0.565*	-0.440*	-0.590*		
			(0.057)	(0.069)	(0.058)	(0.067)		
G2×*y2008*			-0.283*	-0.546*	-0.352*	-0.570*		
			(0.059)	(0.072)	(0.065)	(0.069)		
G2×*y2013*			-0.382*	-0.568*	-0.466*	-0.588*		
			(0.059)	(0.068)	(0.056)	(0.067)		
ln(*Dist*)×*y1988*							-0.034	-0.046
							(0.032)	(0.033)
ln(*Dist*)×*y1993*							-0.027	-0.039
							(0.028)	(0.035)
ln(*Dist*)×*y1998*							-0.094*	-0.155*
							(0.029)	(0.032)
ln(*Dist*)×*y2003*							-0.127*	-0.216*
							(0.030)	(0.031)
ln(*Dist*)×*y2008*							-0.106*	-0.216*
							(0.026)	(0.030)
ln(*Dist*)×*y2013*							-0.132*	-0.217*
							(0.030)	(0.030)
Constant	0.572*	0.693*	0.600*	0.731*	0.706*	0.763*	0.613*	0.764*
	(0.059)	(0.046)	(0.057)	(0.077)	(0.079)	(0.076)	(0.060)	(0.076)
Two-way FEs	Y	Y	Y	Y	Y	Y	Y	Y
N	126	126	126	126	126	126	126	126
R^2	0.871	0.916	0.881	0.916	0.920	0.933	0.846	0.887

Notes: Keihin: Tokyo and Yokohama ports. Big 5: Tokyo, Yokohama, Kobe, Osaka, and Nagoya ports. Robust standard errors are in parentheses.

* $p < 0.01$

Table 6: Between-year difference

		(1) Export	(2) Import
Between-year Difference	1993–1985	-0.049	-0.093
		(0.056)	(0.084)
	2003–1993	-0.312*	-0.472*
		(0.052)	(0.067)
	2013–2003	-0.022	-0.003
		(0.055)	(0.046)

Notes: The between-year differences are computed based on the estimates of columns 3–4 of Table 5. Robust standard errors are in parentheses.

* $p < 0.01$

Table 7: The impacts on prefecture-year level export and import volumes

	(1) ln(*export volume*)	(2) ln(*import volume*)	(3) ln(*export volume*)	(4) ln(*import volume*)
G2×Postquake	0.610*	0.575*	0.581*	0.624*
	(0.208)	(0.210)	(0.192)	(0.211)
	[0.132]	[0.143]	[0.125]	[0.134]
Constant	10.318*	9.059*	10.771*	9.647*
	(0.086)	(0.136)	(0.073)	(0.115)
Samples	G1 & G2 ex Tokyo MA	G1 & G2 ex Tokyo MA	G1 & G2	G1 & G2
Two-way FEs	Y	Y	Y	Y
N	98	98	126	126
R^2	0.580	0.912	0.563	0.901

Notes: Robust standard errors are in parentheses; Bootstrapped (100 bootstrap repetitions) standard errors are in square brackets. G1 & G2 excluding Tokyo MA: Group 1 and Group 2, excluding the four prefectures: Tokyo, Kanagawa, Chiba, and Saitama; G1 & G2: Group 1 and Group 2.

* $p < 0.01$ (based on the robust standard errors in parentheses)

Table 8: Estimates on manufacturing inputs and outputs, and earnings

	(1) ln(*Value of manufactured goods shipment*)	(2) ln(*Value of raw materials used in manufacturing*)	(3) ln(*Manufacturing earnings p.c.*)
G2×*year*(*1990–1994*)	0.009	-0.016	-0.016
	(0.020)	(0.025)	(0.016)
G2×*year*(*1995–1999*)	0.018	0.001	-0.006
	(0.039)	(0.052)	(0.025)
G2×*year*(*2000–2003*)	0.001	-0.003	-0.004
	(0.048)	(0.065)	(0.035)
G2×*year*(*2008–2013*)	0.016	0.026	0.015
	(0.057)	(0.068)	(0.043)
Constant	8.125*	7.628*	7.848*
	(0.020)	(0.026)	(0.014)
Two-way FEs	Y	Y	Y
N	350	350	350
R^2	0.773	0.663	0.954

Notes: Samples: Group 1 and Group 2, excluding Tokyo MA (Tokyo, Kanagawa, Chiba, Saitama); Annual data for the time periods: 1985–2003 & 2008–2013; data for 2004–2007 are not available; Robust standard are errors in parentheses.

* $p < 0.01$

Figures

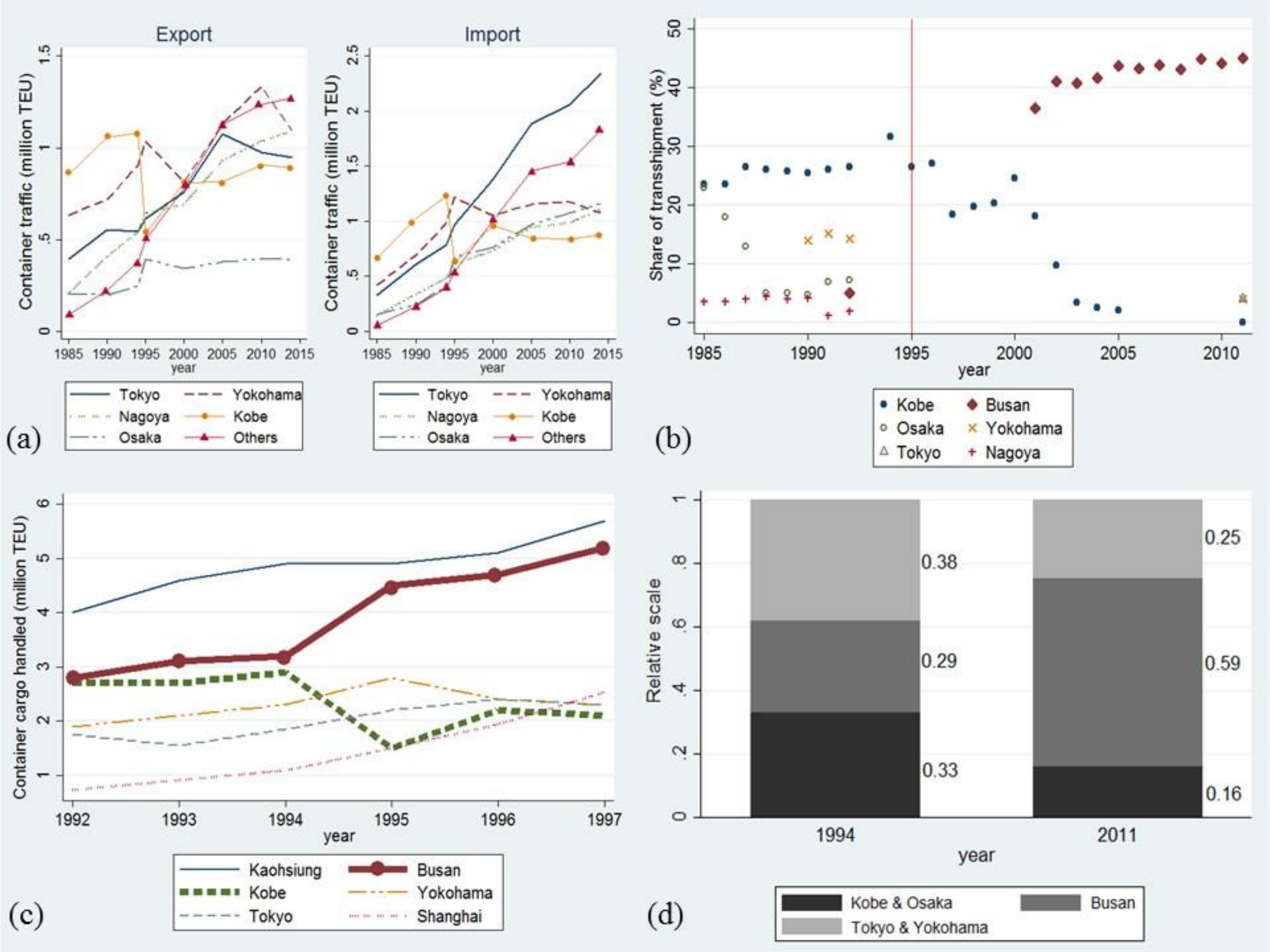

Figure 1: The dynamics of port scale

Notes: (a): The container traffic of five major ports of Japan in selected years, “Others” refers to the container traffic of all of Japan’s regional ports except the five major ports. The data contain information on trading and international transshipment cargoes. Data source: Japan Port Statistics Yearbook, 2012. (b): The share of international transshipment cargoes in the total container traffic in selected ports. Data sources: Data on 1985–1992 for all the ports are from Harada (1996); Data on Busan port (2001–2010) are from Busan Port Authority (2011); Data on Kobe port for 1994–2005 are from Guerrero and Itoh (2016) and Chang (2010); Data for 2011 are from Drewry Shipping Consultants Ltd. (2012) and Port Report of Japan (2012). (c): Container traffic of selected eastern Asian ports. The data include all the containers cargoes landed (including trading, international transshipment, and domestic cargoes). Data source: Containerisation International (1997) and Chang (2000). (d): The relative scale of three port areas. The data refer to: $RelativeScale_{it} = Volume_{it}/\sum_{i=1}^{3} Volume_{it}$, i: port area, t: year. i = Busan port, Hanshin port area (Kobe & Osaka), and Keihin port area (Tokyo & Yokohama). $Volume$ is the annual port-level container traffic measured by TEUs. The container traffic includes all the containers cargoes landed. Data source: Chang, 2000; Japan Port Statistics Yearbook, 2012; Drewry Shipping Consultants Ltd., 2012.

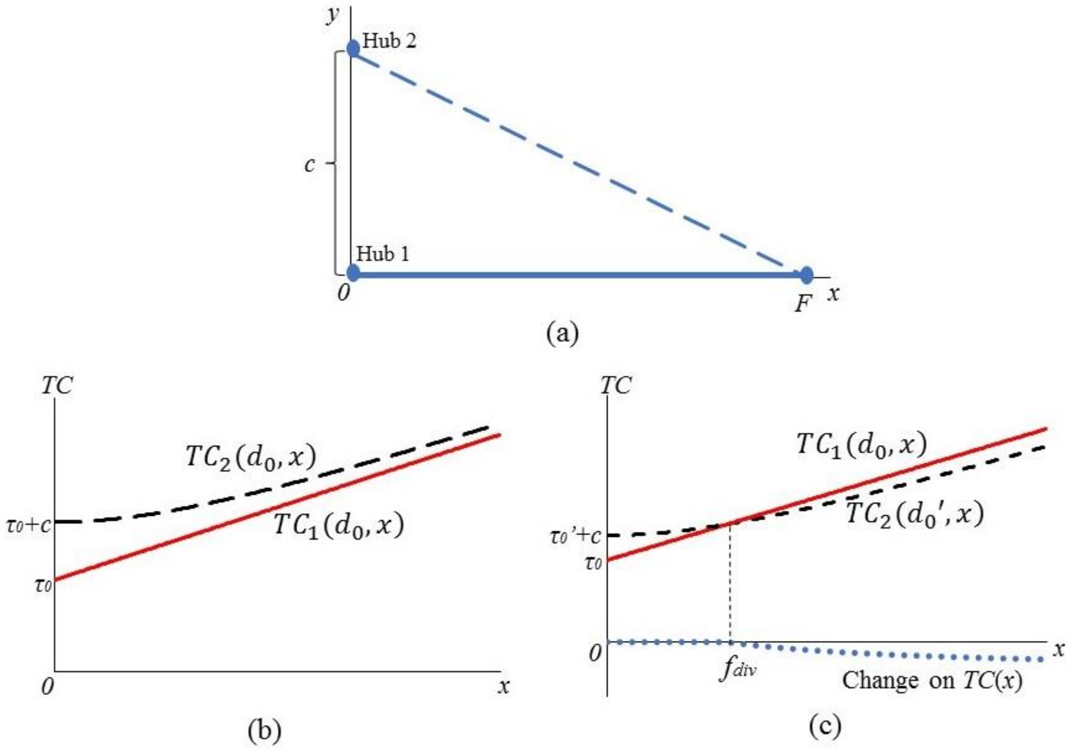

Figure 2: Determinants of transport costs

Notes: (a) shows the locations of shippers and hub ports. Shippers (firms) are located uniformly and continuously in [0, *F*] of the horizontal axis, Hub 1 is located at (0, 0), and Hub 2 is located at (0, *c*). For a shipper located at (*x*, 0) ($x \in [0, F]$), the transport distance to freight a unit of container cargo to Hub 1 and Hub 2 are *x* and $\sqrt{c^2 + x^2}$, respectively. (b) shows the total transport costs for a shipper to freight a unit of container cargo to the international destination (solid line for Hub 1, and dashed line for Hub 2). (c) shows the total transport costs for a shipper to freight a unit of container cargo to the international destination after the exogenous shock on the transport density of Hub 2 (solid line for Hub 1, and dashed line for Hub 2). f_{div} is the threshold distance that, for the firm locations (*x*, 0) ($x \in [0, f_{div}]$), total transport costs via Hub 1 is not higher than Hub 2, while for locations that $x \in (f_{div}, F]$, total transport costs via Hub 2 is lower than Hub 1. The dotted line refers to the change in $TC(x)$ for all the locations after the exogenous shock, that is, shippers in the locations of (*x*, 0) ($x \in (f_{div}, F]$) save cost by diverting the cargoes from Hub 1 to Hub 2.

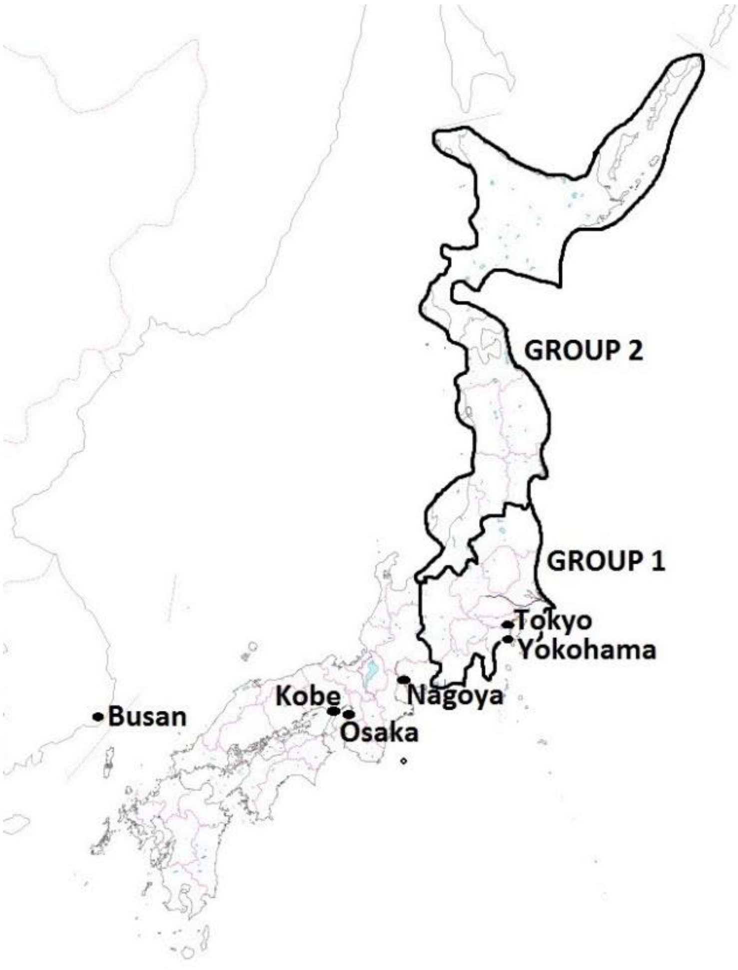

Figure 3: The locations of Group 1 and Group 2

Notes: This map does not include Okinawa prefecture, which is far away from the main island of Japan. Busan (South Korea) is the closest foreign major port for Japan, which is 200 kms away from Kyushu.

Figure 4: The container handling share of Keihin port area in Group 1 and Group 2

Notes: Group 1 includes the prefectures in northern Japan and within 250 kms from Tokyo port; Group 2 includes the remaining prefectures in northern Japan.

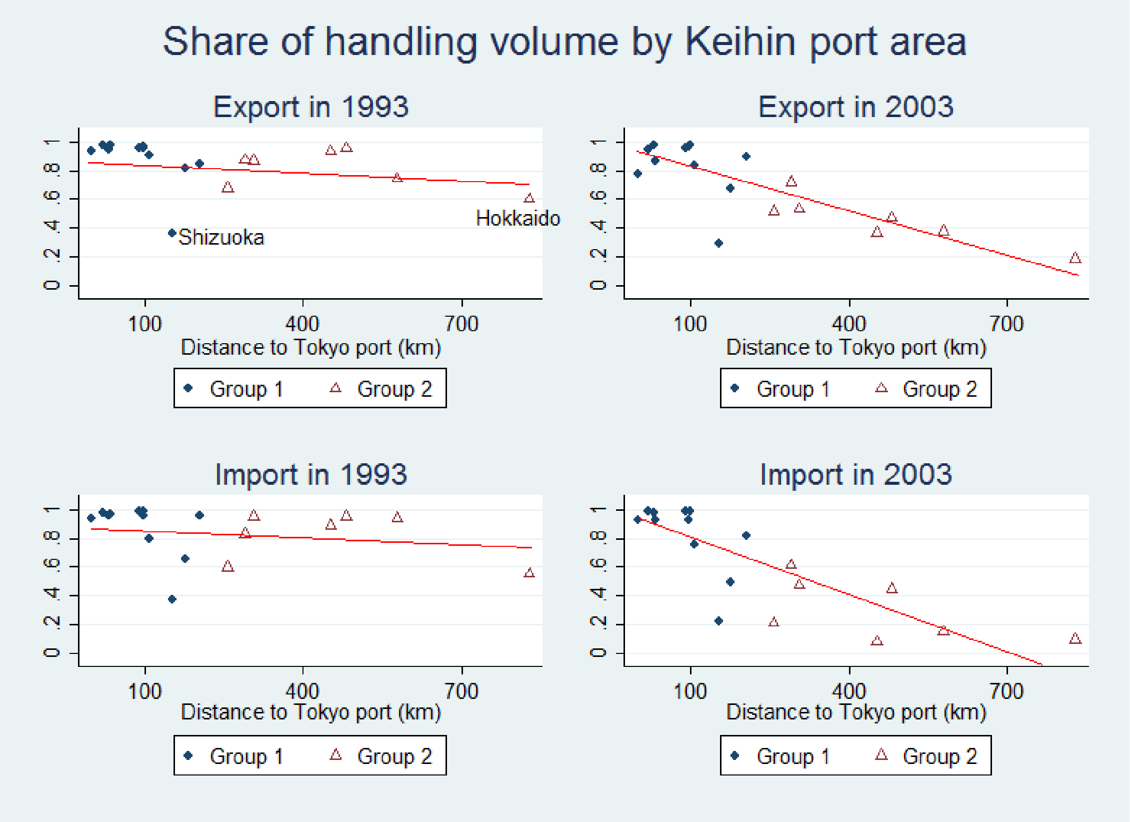

Figure 5: The gradient of container handling share against distance to Tokyo port

Notes: Group 1 includes the prefectures in northern Japan and within 250 kms from Tokyo port; Group 2 includes the remaining prefectures in northern Japan. We take the distance between a prefecture's core district to Tokyo port as the proxy of the distance between a prefecture and Keihin port area.

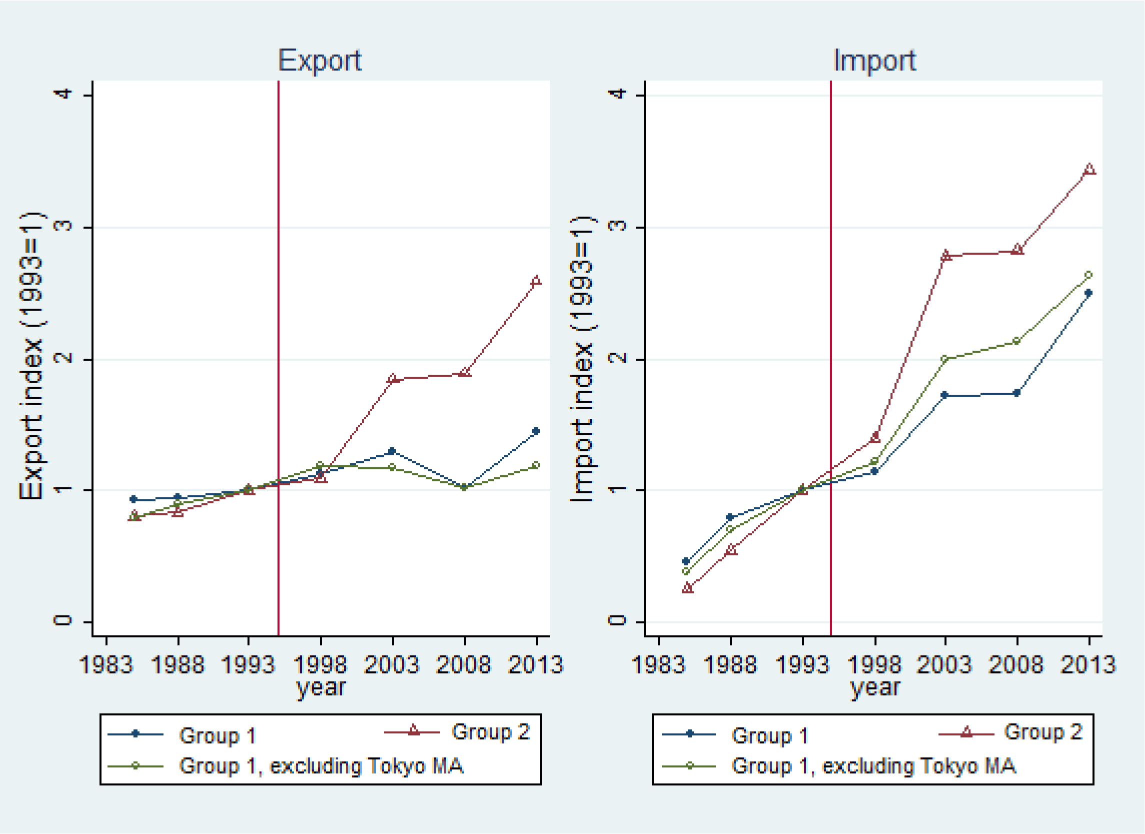

Figure 6: The growth of absolute export/import volume in northern Japan

Notes: Group 1 includes the prefectures in northern Japan and within 250 kms from Tokyo port; Group 1 (ex Tokyo MA) includes the prefectures in Group 1; however, Tokyo, Kanagawa, Chiba, and Saitama are excluded; Group 2 includes the prefectures located more than 250 kms from Tokyo port in northern Japan. The data are normalized based on the related export and import volume in 1993.

Appendix

Table A.1: Changes in ranking of world's major container ports

Rank	1990	1995	2000	2004	2007	2010
1	Singapore	Hong Kong	Hong Kong	Hong Kong	Singapore	Shanghai
2	Hong Kong	Singapore	Singapore	Singapore	Shanghai	Singapore
3	Rotterdam	Kaohsiung	Busan	Shanghai	Hong Kong	Hong Kong
4	Kaohsiung	Rotterdam	Kaohsiung	Shenzhen	Shenzhen	Shenzhen
5	Kobe	Busan	Rotterdam	Busan	Busan	Busan
6	Los Angeles	Hamburg	Shanghai	Kaohsiung	Rotterdam	NB/ZS
7	Busan	Long Beach	Los Angeles	Rotterdam	Dubai	Guangzhou
8	Hamburg	Yokohama	Long Beach	Los Angeles	Kaohsiung	Qingdao
9	NY/NJ	Los Angeles	Hamburg	Hamburg	Hamburg	Dubai
10	Keelung	Antwerp	Antwerp	Dubai	Qingdao	Rotterdam

Notes: NY/NJ: New York/New Jersey; NB/ZS: Ningbo/Zhoushan; Data source: Busan Port Authority (2011).

Table A.2: Data summary (1)

Variable	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
	Group 1					Group 2				
Export_Hanshin	77	0.03	0.03	0.00	0.17	49	0.05	0.05	0.00	0.24
Import_Hanshin	77	0.02	0.03	0.00	0.15	49	0.01	0.02	0.00	0.08
Export_Keihin	77	0.86	0.18	0.23	0.99	49	0.64	0.24	0.17	0.99
Import_Keihin	77	0.84	0.22	0.18	0.99	49	0.56	0.32	0.08	1.00
Export_Big 5	77	0.92	0.15	0.38	1.00	49	0.70	0.25	0.19	1.00
Import_Big 5	77	0.90	0.15	0.38	1.00	49	0.58	0.32	0.09	1.00
Distance to Tokyo port (kms)	11	94	63	10	206	7	457	188	258	829

Notes: *Export_Hanshin* refers to the share of a prefecture's container cargoes (export) that are handled by Kobe and Osaka ports. *Export_Keihin* refers to the share of a prefecture's container cargoes (export) that are handled by Tokyo and Yokohama ports. *Export_Big 5* refers to the aggregated share of a prefecture's container cargoes (export) that are handled by Kobe, Osaka, Tokyo, Yokohama and Nagoya ports. The indicators for import are analogous. Data are for 18 prefectures in seven years (1985, 1988, 1993, 1998, 2003, 2008, 2013). For Tokyo prefecture, the distance to Tokyo port is set as 10 kms. For other prefectures, the distance is measured based on the geographical distance between the prefectural core city to Tokyo port. Data source: Computed based on CCFS; distance data are calculated based on the latitude and longitude information.

Table A.3: Empty container incidence by region

Region	1980	1990	2000	2007	2008	2009
North America	21.2	20.6	22.5	22.5	20.9	20.7
Latin America	30.8	38.2	33.1	25.9	26.5	27.2
West Europe	21.0	20.6	19.1	21.2	20.9	20.6
Eastern Europe	20.3	28.2	24.2	29.3	29.1	28.2
Far East	17.9	16.1	19.5	19.5	19.6	19.5
South East Asia	18.7	15.3	18.2	16.9	16.7	17.2
South Asia	24.2	17.4	16.4	16.9	16.8	16.8
Middle East	38.3	27.1	26.8	27.1	23.2	28.5
Oceania	20.0	20.3	20.3	20.2	20.9	21.2
Africa	20.9	25.2	27.0	28.6	28.0	28.2
World	21.7	20.2	21.2	21.0	20.7	21.0

Notes: Empty container incidence is expressed in percentage points. *Region* refers to the location of traders. For example, *North America* in 1980 means the average empty container incidence in 1980 for all the container cargoes departing or arriving at North America. Data source: Drewry Shipping Consultants Ltd., 2010a.

Table A.4: Data summary (2)

Variables	Data source	Data frequency	Obs.	Mean	Std. Dev.	Min	Max
Export volume (tonnage)	CCFS	Five-year interval	126	123,817	133,220	4,460	687,709
Import volume (tonnage)	CCFS	Five-year interval	126	160,845	214,632	371	947,539
Value of raw materials used in manufacturing (billion yen)	JSY; HSJ	Annual	350	3,158.74	2,305.11	607.85	11,748.00
Value of manufactured goods shipment (billion yen)	JSY; HSJ	Annual	350	5,411.64	3,914.19	1,000.41	19,178.00
Manufacturing earnings p.c. (thousand yen)	JSY; HSJ	Annual	350	3,571.61	716.75	1,965.25	4,864.42

Notes: Export and import volume data are for 1985 and 1988–2013 (at five-year interval). Manufacturing values and earnings data are for the time periods 1985–2003 & 2008–2013; however, data for 2004–2007 are not available. CCFS: Container Cargo Flow Survey; JSY: Japan Statistical Yearbook, 2011–2016; HSJ: Historical Statistics of Japan (http://www.stat.go.jp/english/data/chouki/08.htm) (Statistical Bureau, Japan).

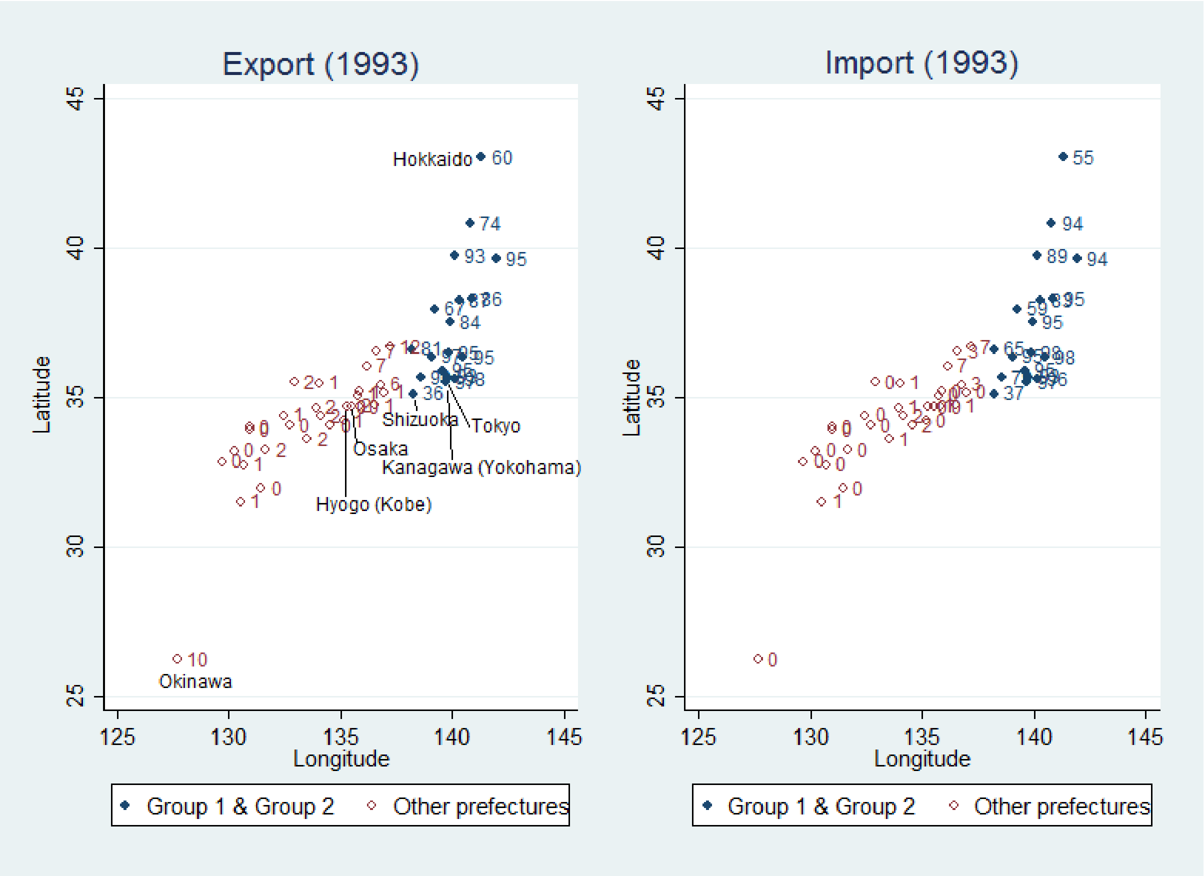

Figure A.1: The prefecture-level container handling share of Keihin port area in 1993

Notes: The number in the right-hand side of each dot refers to the percentage point of a prefecture's container handling share of Keihin port area. Longitude and latitude refer to a prefecture's geographical location. Data source: Computed based on CCFS.

Figure A.2: Prefectures of Japan

Notes: This map does not include Okinawa prefecture.

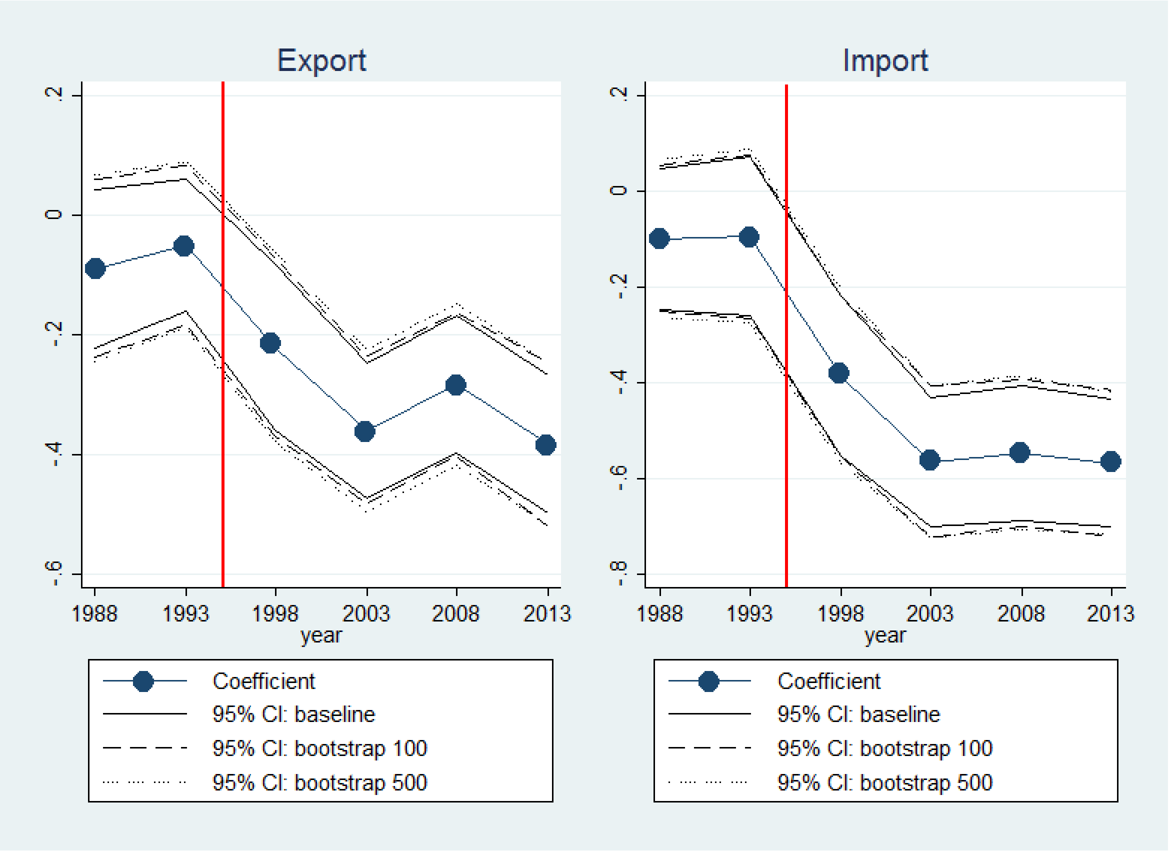

Figure A.3: The dynamic effects of the Hanshin earthquake on port choice: bootstrapping estimation

Notes: The coefficient refers to the estimates of β_t in equation R.2 by year, with 1985 as the reference year (coefficients of column 3 of Table 5 for export, and column 4 for import). Solid, dashed, and dotted lines refer to the 95% confidence intervals (CI) based on the robust standards errors (baseline), bootstrapped standard errors (100 bootstrap repetitions), and bootstrapped standard errors (500 bootstrap repetitions), respectively.