Will Structure-Environment-Fit Result in Better Port Performance?

—An Empirical Test on the Validity of Matching Framework Theory

Abstract

Although Matching Framework Theory (MFT) was introduced to explain inconsistencies in the port performance literature more than two decades ago, empirical studies to test its validity are absent. In this paper, we conduct an empirical study—focusing on one dimension of MFT, structure-environment-fit—and its impact on port performance. We deliberately select the Chinese container terminal industry (2004–2014) to test the proposed theory. We assume that the 2008 Financial Crisis in the middle of our observation period significantly changed the original structure-environment-fit state in the context, thereby resulting in a different impact on port performance. The event study research design also enables us to examine the influence of structure-environment-fit on port performance, while leaving other variables relatively stable. A multivariate analysis model in the truncated double bootstrapping method, median regression and a meta-frontier analysis are applied to prove our hypotheses. The results obtained based on data of 56 Chinese container terminals from 2004 to 2014 confirm that structure-environment-fit results in better port performance.

Keywords: Matching framework theory, Port performance, Event study, Ownership-structure

1 Introduction

Although port performance is one of the most important research topics in port economics, academia has experienced a long journey to answer the question, what leads to better port performance, without a consensus being reached. Various predictors of better port performance have been identified, including management factors—such as port assets, berth quantity, or the reliability of port schedules and shipping networks (Kang and Woo, 2017; Wanke et al., 2011; Yeo et al., 2008)—governance structure (Yuen et al., 2013); geographical factors, such as geographic location (Sun et al., 2017) or hinterland connectivity (Gekara and Chhetri, 2013); social-economic environment factors, such as the industrial governance model (Zheng and Negenborn, 2014) or the local supply chain system (Song and Panayides, 2008; Stevens and Vis, 2016); etc. Some research generates mix results. In their seminal theoretical article, Baltazar and Brooks (2007) attempt to fill this gap by introducing 'Matching Framework Theory' (MFT), which is rooted in configuration theory, suggesting 'there is no best way but an appropriate way to manage for a given context'. Unfortunately, in the past two decades, limited research has empirically tested the validity of the theory in the port industry. By a thoroughly designed event study research and a unique and manually collected database including data of 56 Chinese container terminals from 2004–2014, our research aims to fill the gap by testing whether (ownership) structure-environment-fit will result in better port performance, as Baltazar and Brooks ascertain. Our empirical research is one of the pilot studies attempting to empirically test the validity of MFT and contributes to the port performance literature accordingly.

2 Literature Review

'What leads to better port performance' has long been discussed in port economic research and has created a large body of literature that falls into three categories. (1) ***Management factors*** focus on operational and management issues, including [a] *infrastructure investment*—such as berth length, number of berths, number of cranes, terminal area, and the size of the parking lot for incoming trucks (Rios and Maçada, 2006; Wanke et al., 2011; Yeo et al., 2008)—and [b] *operational management*—such as the frequency of cargo loss and damage, prompt response, delay time for mooring/loading cargo/unloading cargo, port safety, and the reliability of port schedules (Cabral and Ramos, 2014). (2) ***Geographical factors*** include [a] *geographic locational advantages*, which are generally interpreted as 'closeness to the main navigation route', 'closeness to the import/export consumption areas', and 'proximity of the feeder ports' (Lirn et al., 2003). Shippers may favor one port over another due to cost savings, time savings and transport flexibility (Brooks, 2000; Starr, 1994). Geographical factors also include [b] *hinterland and hinterland connectivity*. Yeo and his colleagues note, "as the condition of the hinterland increases, so does a port's competitiveness" (Yeo et al., 2008, pp 918). Conversely, port performance can easily be undermined by poor hinterland connectivity (Gekara and Chhetri, 2013). (3) ***Social-economic environment factors*** are related to the 'upper-level systems' within which ports are operated (Cheon et al., 2010; Panayides et al., 2015), such as the industrial governance mode (Zheng and Negenborn, 2014), the local supply chain system (Song and Panayides, 2008; Stevens and Vis, 2016), etc.

Several studies focus on the relationship between governance structure and port performance. For example, in the Greek port-reconstructing case, Pallis and Syriopoulos (2007) find that a transition from 'public law undertakings' to government-owned port corporations does not necessarily result in better financial performance, and the further steps of modernization and restructuring are essential. Similarly, the port privatization case in the UK also highlights the importance of the method and approach used in the reform in terms of port performance improvement (Baird and Valentine, 2006). Yuen et al. (2013) empirically test the relationship between foreign ownership and port performance. The result indicates that having some Chinese ownership may benefit port performance, for it can 'facilitate the cooperation with Chinese-owned upstream and downstream players' (Yuen et al., 2013). Meanwhile, some empirical studies in this area focus on various industries. For example, Yin and Zajac (2004) examine strategy-governance structure fit and its impact on corporate performance using longitudinal data from one of the biggest U.S. restaurant chains from 1991 to 1997. Similarly, Zott and Amit (2008) propose that product market strategy-business model fit can enhance firm's performance. Based on data from 2204 acquisitions in the U.S. commercial banking industry from 1989 to 2001, Kim and Finkelstein (2009) find that strategy-market fit has a positive impact on acquisition performance. The above-mentioned literature in general management studies departs from traditional debates regarding the superiority of one attribute over another and argues that the difference in performance may be rooted in the matching of one attribute with another. Quantitative research adopting similar principles is limited in the port performance literature.

Although academia produces a rich literature on the impact of governance structure on port performance, the results are mixed. For example, Zheng and Negenborn (2014) assert that port performance is better under a decentralized governance mode, while Brooks and Cullinane (2007) conclude, 'deregulation has a negative impact on efficiency in the short term, as there are costs incurred ingoing from a regulated environment'(Brooks and Cullinane, 2007, pp. 634). More importantly, most of this literature 'appl[ies] the "one best way" principle' to port performance, neglecting the existence of an alternative approach that views port performance as 'a function (output) of the match (or fit) among the characteristics of the organization's external operation (or task) environment, strategies and structures. The greater the fit, the better the expected performance will be; the poorer the fit, the worse the expected performance will be' (Baltazar and Brooks (2001), *also see* Fig. 1). Unfortunately, although MFT seems quite appealing and convincing, limited empirical research has been conducted to test its validity since the theory was put forward almost two decades ago. Motivated by this fact, the object of this pilot study is to make a first attempt to empirically investigate the validity of MFT and address our research question, 'Will structure-environment-fit result in better port performance?'.

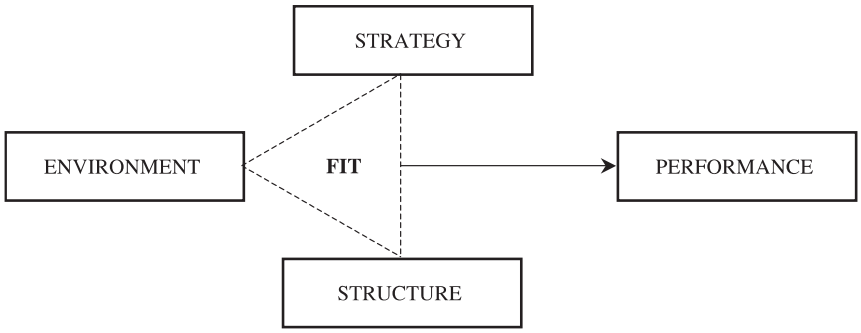

Fig. 1. Matching Framework Theory

Source: Baltazar and Brooks (2001).

Most of the extant literature has adopted an attributes model, suggesting port performance is an outcome of various input factors—such as management (Cabral and Ramos, 2014), geographical (Gekara and Chhetri, 2013) and social-economic environment factors (Zheng and Negenborn, 2014). Meanwhile, this research contributes to our understanding of port performance by viewing the construct as a dynamic matching process between the structure and the environment. We do not intend to undermine the validity of MFT as an integrated theoretical framework for port performance interpretation. On the contrary, given the difficulties in research data collection and methodology, as noted in their original paper (Baltazar and Brooks, 2007), our first step forward is to partially test the validity of one of MFT's three dimensions and to make significant theoretical contributions accordingly.

3 Context Selection and Hypotheses Development

3.1 Context Selection

MFT suggests there is no best way, but an appropriate way, to manage for a given context (Baltazar and Brooks, 2007). Port performance is viewed as an outcome of fitness among environment, structure and strategy. The highly contextualized nature of MFT requires its empirical studies to be conducted in a context deliberately selected in accordance with the research question. Therefore, technically, as our research aims to test whether structure-environment-fit will result in better port performance, the context qualifying for this research should have the following characteristics: 1) an appropriate number of ports with different structure-environment-fit states to satisfy the requirement for data statistical processing, and, 2) ideally, to more accurately identify the relationship between structure-environment-fit and port performance, an exogenous shock that significantly changes the state of the original structure-environment-fit in every port, thereby affecting their performance accordingly. The latter criterion accords with the basic idea of the event study method (Gilson and Black, 1995). The event study method is an empirical study method in which firms or individuals are exposed to external shock determined by nature or by other factors outside the control of the investigators. This method enables observers to more accurately identify changes in outcomes attributed to certain conditions contained in the exposure (Dunning, 2012).

We find that the development of the Chinese container (terminal) industry perfectly matches the proposed research context, as it experiences with an exogenous shock/exposure, the 2008

Financial Crisis, in the middle of the observation period of 2004-2014[1]. The 2008 Financial Crisis provides an appropriate event study setting, as it significantly affects transportation demand (*see* Fig. 2) while leaving other variables relatively stable. Therefore, we can analyze endogeneity issues at the terminal level. Data regarding container terminals from 2002 to 2012 are represented in Fig. 2, which supports our statement by indicating a significant decline in 2008 with a steady downward trend throughout the entire period. If we consider the rigidity of port construction, we have solid grounds to expect that, prior to 2008, container terminals in China enjoyed a comfortable external environment in terms of adequate import and export cargo. After 2008, a significant drop in transportation demand led to overcapacity in the container terminal sector, which placed greater importance on 'soft' capabilities such as canvassing and providing logistics solutions. Thus, the 2008 Financial Crisis fundamentally changed the industrial environment by subverting the comparative relationship between demand and supply. Its profound impact on the port industry is unparalleled by other external environment factors during this period (Ng and Liu, 2010). Therefore, our research design might be flawed, but it captures major issues in context.

[1]Although Chinese ports' private sector involvement can be traced to Yantian International Container Terminal's case through joint venture in the 1980s (Child et al., 2012), no public container-terminal-level data are available until 2004, when the Chinese Port Yearbook began to provide a separate section on container transportation nationwide. Moreover, data collected from the Chinese Port Yearbook 2004 are teased from our dataset duo to missing-data issues. Therefore, our observation period starts from 2004.

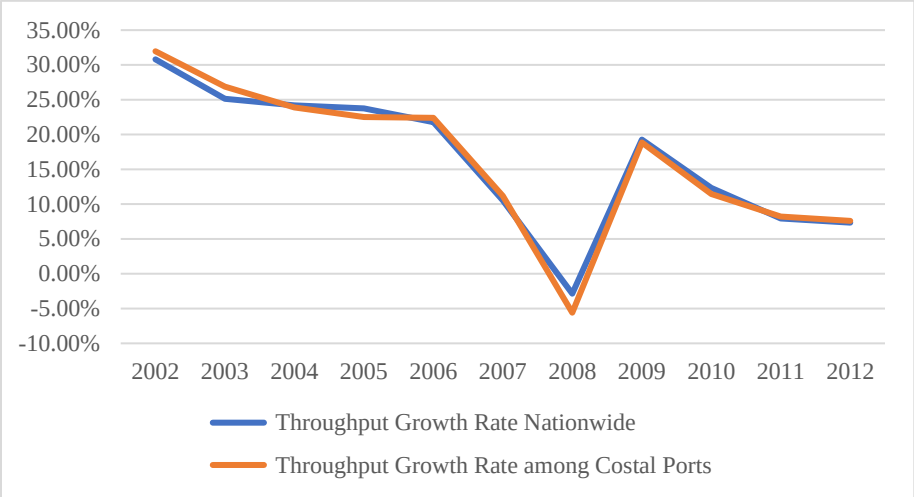

Fig. 2. Container Terminal Throughput Growth Rate (2002–2012)

Data Source: Chinese Port Year Book 2003–2013

The 'structure' component in our research refers to the ownership structure, specifically, the proportion of foreign ownership of container terminals, which affects operating procedures, information and control systems, as identified in MFT (Baltazar and Brooks, 2007; Bourgeois et al., 1999).

The environment in our research refers to the industry environment, which can affect port industry's participants (Baltazar and Brooks, 2007). Specifically, it refers to the relative relationship between container handling demand and supply in the Chinese container terminal industry. Fig. 2 demonstrates a significant decline in container handling demand in 2008 due to the financial crisis. Considering the rigidity of port construction, we propose that the Chinese container terminal industry experienced a transition from adequate demand to overcapacity, which is also evidenced by Xingang Su's, Vice-President of China Merchant Group, statement in 2010:

China's port industry is experiencing an imbalance in its supply-demand structure. The capacity is up to 40% ahead of schedule. The surplus is obvious. Even if the construction of port terminals were to be discontinued, the industry would require at least three years to recover from the imbalance (Tao, 2010)

In the following section (section 3.2), we discuss ownership structure-environment-fit and its impact on port performance against the background of the Chinese container terminal industry (2004-2014) and develop our hypotheses accordingly.

3.2 Hypotheses Development

Resource-Based-View (RBV) scholars in strategic management emphasize firm-level heterogeneity and argue that a competitive advantage is generated by the possession of resources that are unique, valuable, scarce and difficult to imitate (Wernerfelt, 1984; Barney, 1991). These scholars assert that these resources are composed of material resources, human resources and organizational structural resources. Grant (1996) modifies the RBV and proposes that knowledge, not resources, generates a competitive advantage. He also indicates that the firm functions as an institution integrating both tacit and explicit knowledge. International business scholars refer to these ideas to explain why joint ventures' (JVs') performance appears to be better than that of their competitors operating in a host country and fully owned by local capital. Establishing joint ventures with Multinational Corporations (MNCs) through foreign direct investment appears to be a wise choice for companies operating in developing countries seeking capital, advanced

technology and various types of skills. Vance and Paik (2015) identify six capabilities that host country partners may gain from JVs, including the MNC predominant language, MNC home country cross-cultural awareness, supervision and technical operations management skills, and the MNC strategy and culture.

Reflecting on our case, before 2008—when the China port industry experienced a long period of high-speed economic growth—and the throughput nationwide increased rapidly (see Fig. 2), resource and knowledge fall short of market demand. This situation often happens when a region or a country's economy is in the initiating stage, characterized by 1) a labor intensive and/or extensive manufacturing industry requiring basic cargo handling services from port/terminal operators, 2) scarce capital, and 3) rarely found developed operational management skills and specialists because local port operators are inexperienced. Therefore, foreign ownership in port companies can serve as perfect channels for resources and knowledge to the global market (Vance and Paik, 2015). Accordingly, the port could benefit from foreign ownership in terms of capital, developed operational management skills and information technologies to achieve better performance. Thus, our first hypothesis is as follows:

H1. Before 2008, when the proportion of foreign ownership is higher, the match between structure and external environment is better, resulting in better port performance.

On the other hand, foreign ownership may also result in a disadvantage, which is usually generalized as the liability of foreignness (Bell et al., 2012; Kindleberger, 1969). The liability of foreignness refers to the negative effect of doing business abroad resulting from "(1) costs directly associated with spatial distance, such as the costs of travel, transportation, and coordination over distance and across time zones; (2) firm-specific costs based on a particular company's unfamiliarity with and lack of roots in a local environment; (3) costs resulting from the host country environment, such as the lack of legitimacy of foreign firms and economic nationalism; (4) costs from the home country environment" (Zaheer, 1995, pp. 343).

In our case, advantages generated from foreign ownership will be reduced because — compared with high-tech industries, such as the pharmaceutical industry or the chemical industry—the port industry is capital-intensive and lacks innovation in both technology and management practice. On the other hand, lean production in the manufacturing industry requires high quality and customized logistics services, including just-in-time, zero inventory and logistical financial services, etc. This trend in transport demand is further enhanced by the dramatic decline in throughput growth nationwide after 2008 due to the fierce competition among terminals. Most of the leading terminal operators must face challenges from third-party logistic companies, which excel at providing door-to-door logistic services solutions. For example, on July 27, 2019, SF Express, the leading door-to-door logistic service provider in China, released its new strategy to enter the international shipping business, providing arrive-on-time service and real-time tracking system to their customers. This strategy could be interpreted as a competitive pressure on port

operators in China, who attempt to increase their revenue by providing various value-added services. Furthermore, empirical studies indicate that socially embedded organizations with various types of ties and relationships may facilitate coordination among different participants in the supply chain (Song and Panayides, 2008; Stevens and Vis, 2016). These ties, such as *guanxi*, are not only economically but also socially and culturally embedded in local communities, including manufacturers, banks, and government agencies. Local firms can easily benefit from these ties, while outsiders struggle with the liability of foreignness (Zaheer, 1995). Therefore, we propose our second hypothesis, as follows:

H2. After 2008, when the proportion of foreign ownership is higher, the match between structure and external environment is less, resulting in poorer port performance.

H1 and ***H2*** demonstrate the relationship between structure-environment-fit and port performance from two different perspectives. In the following section, we will empirically test these hypotheses to verify the validity of MFT.

Combined with the context selection in section 3.1, our basic idea to address the causality between Structure-Environment-Fit and port performance, instead of relationship, by using the event-study research design can be summarized in Fig. 3.

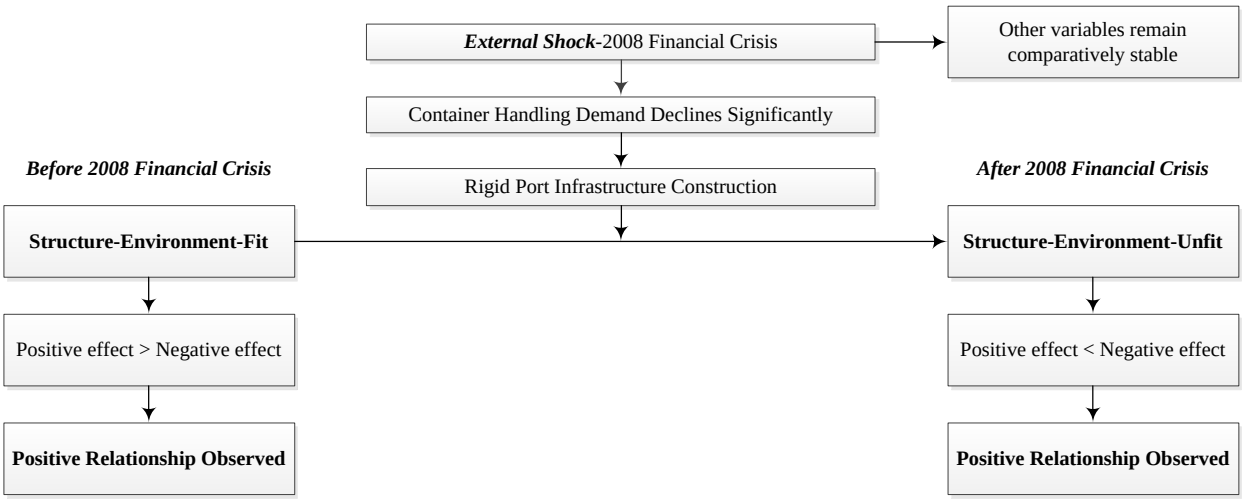

Fig. 3. Basic Idea of Our Research Design

4 Methodology and Data Description

4.1 Research Framework

We aim to prove our hypotheses with multiple econometric tools. The research framework is shown in Fig. 4. ***Firstly***, we apply the input-oriented data-envelopment analysis (DEA) model to estimate the performances of each port, then we use the t-test as a univariate analysis to disentangle the impacts of different structure-environment-fits on port performance. ***Secondly***, the multivariate analysis model is adopted to further examine these impacts on port performances obtained from the input-oriented DEA- Banker-Charnes-Cooper (DEA-BCC) model by controlling some alternative interpretations. In particular, as both positive and negative effects may exist in both periods, the statistical outcomes of foreign ownership's effect on port performance should be considered as a combination of the two effects. Accordingly, a positive and significant result should be interpreted as the positive effect being stronger than the negative effect, while a negative and significant result should be interpreted as the positive effect being weaker than the negative

effect. ***Finally***, to ensure the reliability of our results, we conduct truncated double bootstrapping (Simar and Wilson, 2007, 2011) to avoid any potential serial correlation among the estimated coefficients in the second-stage regression (Yuen et al., 2013). We also use median regression to prevent the influence of outliers in estimated port performance and controlling variables (Koenker, 2005). Moreover, we follow the methodology proposed by O'Donnell et al. (2008) and Chang and Tovar (2017) to reexamine our hypotheses based on the metafrontier analysis to avoid potential errors resulting from the 'all terminals are operated under the same production technology' assumption contained in the input-oriented DEA-BCC model.

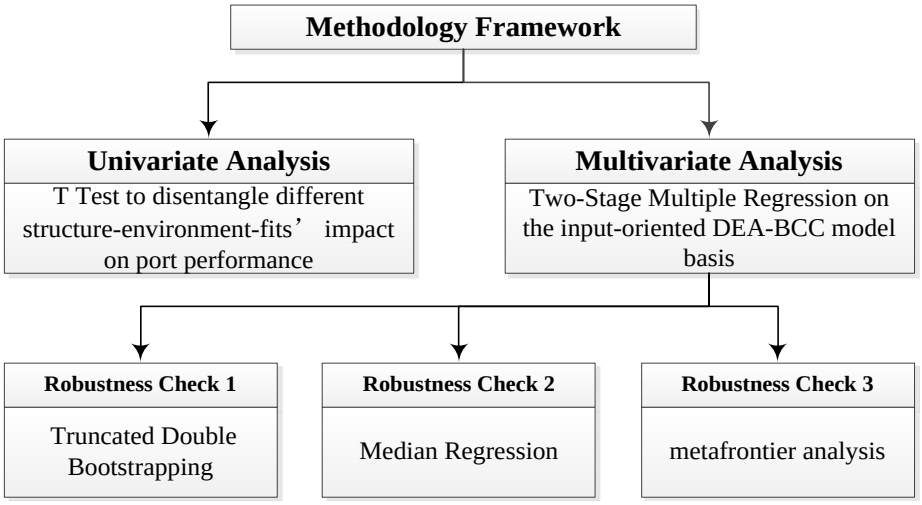

Fig. 4. Research Framework

4.2 Multivariate Analysis Models

We apply two sets of multivariate analysis models to test our hypotheses. First, we set up a benchmark model to test the hinterland effect, the impacts of inter-/intra-port competition and some firm characteristics. For each port *i*, the models are specified as:

$$\text{Port performances}_i = \beta_0 + \beta_1 HinterlandEffect_i + \beta_2 InterportCometition + \beta_3 IntraPortCompetition + \sum \beta_j FirmCharacters_i + \varepsilon_i$$

Then we introduce foreign ownership into the benchmark model to fit the matching theory framework. The model is changed to:

$$\text{Port performances}_i = \beta_0 + \beta_1 Foreignownership + \beta_2 HinterlandEffect_i + \beta_3 InterportCometition + \beta_4 IntraPortCompetition + \sum \beta_j FirmCharacters_i + \varepsilon_i$$

where ε_i means the random disturbance for port *i*. In the following section, we provide the definitions of the proxy variables for each construct. As our proposed theory suggests, the global financial crisis plays a role in the distinct effect of foreign ownership. Then our model would be piece-wise, and we apply models (1) and (2) to the pre- and post-crisis periods to capture the piece-wise pattern.

4.2.1 Port Performance

Baltazar and Brooks (2007) suggest that port performance can be designated as efficiency oriented or effectiveness oriented according to the external environment in which it operates. For an external environment characterized by 'low uncertainty in the organization's operating environment, a narrow product-market scope or a cost leadership approach to product and service

delivery, and a high level of structural centralization and standardization' (Baltazar and Brooks, 2007, p. 391), the efficiency-oriented measurement is most fitted. Compared with other sectors in the port industry, such as general cargo terminals, the container terminal industry is featured by standardization, which significantly reduces the uncertainty associated with cargo-related activities both inside and outside the terminals. Therefore, consistent with Baltazar and Brooks' (2007) suggestion, we adopt an efficiency-oriented approach to measure port performance in our research.

The approaches adopted to analyze port efficiency can be divided into two categories: non-parametric methods (e.g., data envelopment analysis, DEA) and parametric methods (e.g., stochastic frontier analysis, SFA in short) (Fare et al., 1997). Cullinane et al. (2006) find that the DEA and SFA calculations for port efficiency are highly correlated. However, some studies indicate that the SFA possesses significant weaknesses. For instance, the SFA imposes specific functional forms (e.g., the Cobb-Douglas function) on the estimation and specific distributions of error terms. SFA results are dependent on the regression method used. When the SFA model is applied to production with multiple outputs and inputs, it requires further restrictions (Coelli and Perelman, 2000). Unlike the SFA, the DEA is not subject to these requirements. The DEA uses linear programming techniques rather than estimating the efficiency frontier. Therefore, we utilize the DEA to evaluate port efficiencies for our study.

DEA models can be divided into two categories: DEA-CCR (Charnes-Cooper-Rhodes; constant returns to scale) and DEA-BCC (variable returns to scale). Jara-Diaz et al., (2002, 2005)

indicate that ports possess obvious characteristics of variable returns to scale. Therefore, the DEA-BCC model is adopted for this study. Various input and output variables have been applied in DEA analysis; we summarize them in Table 1.

Table 1. Input and output variables in the existing studies

Author	Sample	Model	Variables	
			Input	Output
Roll and Hayuth (1993)	Hypothetical case, 20 ports included	DEA	(1) The annual capital invested in the port and its facilities (2) Uniformity of cargo	(1) Total cargo level of service (2) Customer satisfaction (3) Number of ships
Song and Cui (2014)	24 Chinese container terminals 2006-2011	DEA	(1) Number of staff and workers (2) Number of bridge cranes (3) Quay length	Container throughput
Yuen et al. (2013)	21 Chinese container terminals 2003-2007	DEA	(1) Number of berths (2) Berth length (3) Land size (4) Number of quay cranes (5) Number of yard gantries	Container throughput
Serebrisky et al. (2016)	61 container ports in Latin America and the Caribbean 1999-2009	SFA	(1) Berth length (2) Port area (3) Number of mobile and quay cranes (4) Number of STS gantry cranes	Container throughput
De Oliveira and Cariou (2015)	200 international container ports 2007-2010	DEA	(1) Port area (2) Storage area (3) Length of berth (4) Number of yard cranes (5) Number of quay cranes	Container throughput

To obtain the efficiencies of the prescribed ports, we use container throughput as the output variable and the numbers of staff, bridge cranes and berth length as the input variables. We collect the unbalanced pool data for 56 terminals from 2004 to 2014. Descriptive statistics for the input and output variables are shown in Table 2.

Table 2. Descriptive statistics of input and output variables

Variables	N	Mean	Std	Min	Q1	Median	Q3	Max
Number of staff and workers	490	450.52	312.55	45	226	366	581	2063
Number of bridge cranes	490	11.12	8.99	1	4	8	14	60
Berth length	490	1117.76	737.82	114	582	910	1380	4090
Container throughput	490	1691312	2060468	1848	349336	962854	2330081	17038817

4.2.2 Foreign Ownership

Marked by Hutchison's investment in the Shenzhen Port in the early 1980s, the Chinese government demonstrated a determination to develop the domestic economy through foreign ownership. However, foreign investors were not allowed to control JVs until April 1, 2002, when The National Development and Reform Commission issued the *Catalogue of Industries for Guiding Foreign Investment 2002*, which deregulated foreign ownership in the maritime sector. To clarify, since April 1, 2002, foreign investors can hold 50% or more shares of JVs in the marine sector, which represents complete control of a JV in terms of both operational and financial management. Theoretically, foreign investors can now hold any proportion of shares ranging from 0% to 100%. When foreign investors hold more shares, they offer more resources and capabilities to the JVs. We refer to foreign ownership as those companies whose controlling shareholders are from outside mainland China. Therefore, companies such as Hutchison Port Holdings (HPH) are deemed foreign companies in our research because the controlling shareholders, including Mr. Li Ka-Shing, are from Hong Kong, China.

Fig. 5 annotates the ports with and without foreign participation. Our sample involving foreign participation includes 29 of 59 ports.

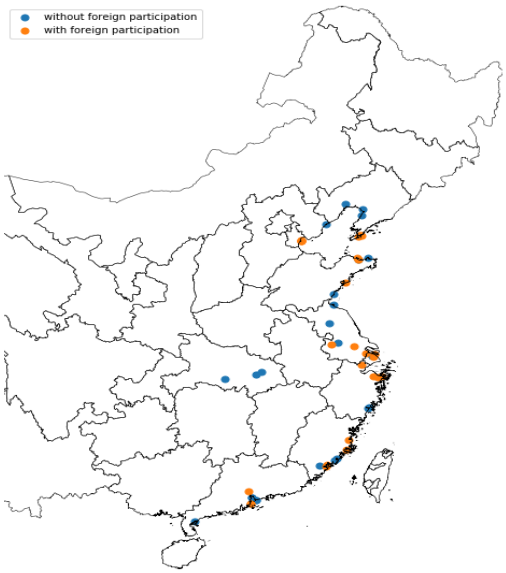

Fig. 5. Ports with and without Foreign Participation

Table 3 summarizes the information about foreign ownership over the years. Columns 2 and 3 of Table 3 report the yearly number of terminals with and without foreign participation, respectively. The last two columns of Table 3 report the means and standard deviations of foreign ownership for terminals with foreign participation. The results show the foreign ownership of terminals in China is stable to a certain extent over time.

Table 3. Yearly summary of terminals' foreign ownership

Year	Number of terminals		Percentage of foreign ownership (%) *	
	with foreign participation	without foreign participation	Mean	Std
2004	13	14	47.46	0.68
2005	15	16	51.13	1.49
2006	15	19	51.13	1.49
2007	21	20	48.14	1.62
2008	25	28	46.23	1.73
2009	24	28	46.12	1.77
2010	26	27	47.96	1.90
2011	27	24	47.85	1.87
2012	27	25	47.85	1.87
2013	25	24	44.97	1.76
2014	23	24	46.17	1.56

**: The columns for percentage of foreign ownership are based on terminals with foreign participation*

4.2.3 Control Variables

To better identify the relationship between ownership structure and port performance before and after the 2008 Financial Crisis, we control for the hinterland effect, inter-terminal competition, intra-terminal competition, firm size, and firm age in our model.

Hinterland Effect

The hinterland is often defined as the area within a certain radius of a port and is measured by the population and/or GDP within this area (Yuen et al., 2013): 'as the condition of the hinterland increases, so does a port's competitiveness' (Yeo et al., 2008). We measure the hinterland effect by using the GDP of the province where the focal terminal is located based on the following

reasons. First, despite the central government's ambition to develop a domestic transportation system, the Chinese railway industry still operates on a planned economy basis, which hinders the efficiency of the inland distribution system. To the best of our knowledge, Chinese ports are highly dependent on road systems to distribute their cargo; therefore, in theory, the distance ports can reach is unduly shortened. Second, the system of tax distribution between the central and local governments results in local protectionism, which leads to a system in which a considerable amount of the local cargo flows to the local terminal rather than terminals in neighboring provinces.

Inter-Port Competition

Inter-terminal competition may have a different impact on port performance. For example, port efficiency decreases with competition intensity when the closest neighboring port is within a range of 400–800 km; otherwise, it is insignificant (De Oliveira and Cariou, 2015). Therefore, we control for inter-port competition intensity, which is measured by the distance between the focal terminal and the nearest container terminal in our sample (Yuen et al., 2013; Yuen and Zhang, 2009).

Others

In alignment with the research conducted by Yuen et al. (2013), we control for intra-port competition by measuring the number of container port terminal operators in a city as a proxy for intra-port competition. In addition, we control for firm size and firm age. Firm size is measured by the local firm's registered capital to eliminate interference caused by scale economies. Firm age is measured by the years since its establishment to eliminate interference caused by the learning effect.

4.3 Data Collection

The primary data source for this research is the Chinese port yearbook from 2005 to 2015. The Chinese port yearbook, issued by the Chinese Port Association, is the official source of statistical data for the Chinese port industry. It has provided data at the container terminal level since 2004. We derive terminal-level data from the Chinese port yearbook from 2005 to 2015. Our research period includes 103 container terminals and 886 firm-year data entries. We exclude 47 container terminals and 396 firm-year data entries due to missing data. Each firm-year data entry includes the number of employees, the number of container quay cranes, the berth length, the throughput, registered capital and the percentage of foreign ownership. In addition, an online map (Baidu Map, http://map.baidu.com/) is used to determine the proximity of competitors (i.e., distance between terminals).

5 Empirical Results

5.1 Descriptive Results

Based on the DEA-BCC model, the average efficiencies of the 56 Chinese container terminals from 2004 to 2014 are calculated and illustrated in Fig. 6. Overall, average terminal efficiencies increase in the investigating period. However, efficiency is stagnant from 2007 to 2009.

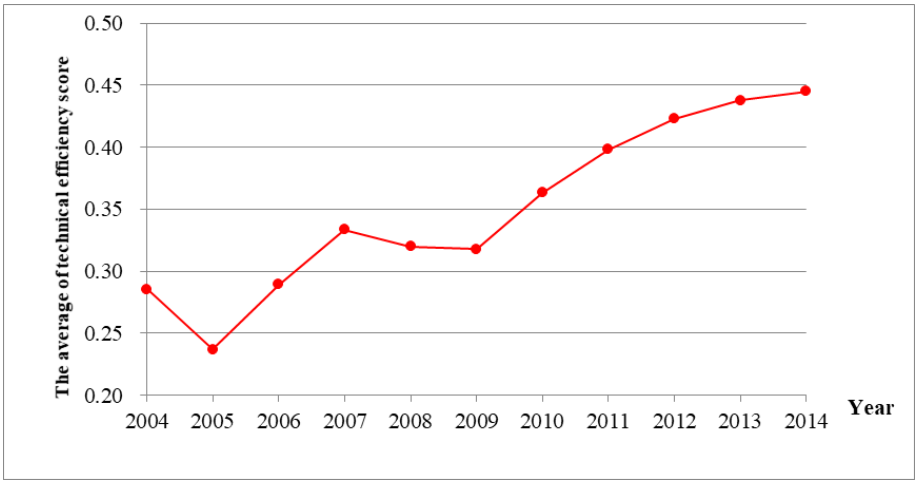

Fig. 6. Average Terminal Efficiencies from 2004 to 2014

Tables 4 and 5 present the descriptive statistics and correlations for each variable used in the ordinary least squares (OLS) regression to examine the relationship between foreign ownership and port performance prior to and following the 2008 Financial Crisis. In particular, Panel A of Table 4 reports the descriptive statistics of the full sample. Our measurements for performance, inter/intra-port competition and firm size show some right-skewed distribution, but the distributions have no visible outliers. Panel B of Table 4 provides the primary comparisons between firms with and without foreign ownership. The results show significant differences between ports with and without foreign ownership. We use the standard *t*-test and the Mann-Whitney U test to examine the differences between these two subsamples. During the whole sample period (2004–2014), the ports with foreign ownership encounter more intra-port competition. In addition, they are larger than state-owned ports and are established earlier, as firm ages suggest.

Table 4. Descriptive statistics of variables

Panel A. Descriptive statistics for the full sample

Variables	N	Mean	Std	Min	P10	Q1	Median	Q3	P90	Max
Performance	490	0.36	0.21	0.00	0.11	0.20	0.34	0.49	0.64	1.00
Foreign ownership	490	0.23	0.26	0.00	0.00	0.00	0.00	0.49	0.50	1.00
GDP (log)	490	10.27	0.69	8.64	9.34	9.82	10.34	10.80	11.10	11.77
Inter-port competition	490	68.54	43.89	16.10	18.60	43.80	62.70	79.70	113.00	192.50
Intra-port competition	490	3.27	2.05	1.00	1.00	2.00	3.00	5.00	6.00	8.00
Firm size	490	1.10	1.61	0.01	0.08	0.29	0.51	1.26	2.57	10.01
Firm age	490	8.16	5.17	1	2	3	8	11	15	26

Panel B. Descriptive statistics and test between firms with and without foreign ownership

Variables	With foreign ownership				Without foreign ownership				*t*-test	U-test
	N	Mean	Std	Median	N	Mean	Std	Median		
Performance	241	0.37	0.20	0.37	249	0.34	0.22	0.28	1.47	7.35***
GDP (log)	241	10.23	0.67	10.22	249	10.31	0.71	10.38	-1.15	2.64
Inter-port competition	241	68.24	38.62	65.90	249	68.82	48.53	61.60	-0.15	3.26*
Intra-port competition	241	3.98	1.99	3.00	249	2.59	1.87	2.00	7.94***	26.65***
Firm size	241	1.35	1.36	0.80	249	0.85	1.79	0.40	3.47***	75.17***
Firm age	241	9.05	4.92	9	249	7.28	5.27	7	3.84***	11.68***

Table 5. Correlation matrix

	Performance	Foreign ownership	Size	Age	Inter-port competition	Intra-port competition	GDP (log)
Performance	**1.00**	0.10*	0.40*	0.05	0.06	0.36*	0.42*
Foreign ownership	0.04	**1.00**	0.36*	0.19*	-0.04	0.37*	0.09
Size	0.30*	0.16*	**1.00**	-0.002	-0.18*	0.34*	0.27*
Age	0.04	0.17	-0.09	**1.00**	-0.08	0.01	0.21*
Inter-port competition	0.06	-0.01	0.01	-0.08	**1.00**	-0.08	-0.38*
Intra-port competition	0.29*	0.34*	0.31*	-0.01	-0.15*	**1.00**	0.27*
GDP (log)	0.43*	0.05	0.24*	0.18*	-0.34*	0.33*	**1.00**

The upper triangle is Spearman correlations, while the lower triangle is Pearson correlations. N=490, *p<0.05

During our whole sample period, Fig. 7 shows that foreign-owned ports may run more efficiently. However, after we plot the performance measurement for ports with and without foreign ownership yearly, the results clearly show that the higher efficiency of ports with foreign ownership mostly comes from the time before 2008. After 2008, the ports owned by the state are more efficient, and the improvements are very persistent.

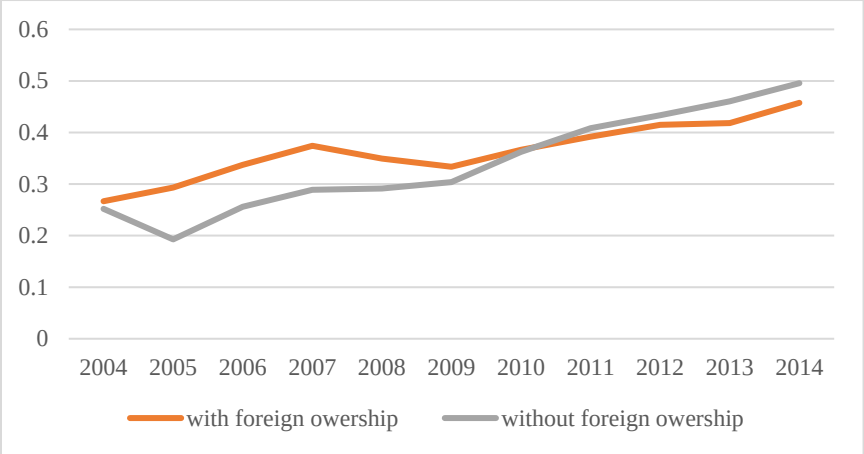

Fig. 7. Average Terminal Efficiency for Ports with and without Foreign Ownership from 2004 to 2014

Although significant inter-correlations exist between certain variables (in Table 5), the maximum correlation coefficient obtained from the Spearman and Pearson correlation tests is only 0.43 (between GDP and performance). Therefore, we do not believe that multi-collinearity significantly affects our results.

5.2 t-*Test Result*

In Table 6, the results from the *t*-test are illustrated. We compare the differences of performances before and after the global financial crisis for foreign-participating and state-owned ports. The results confirm that, before the global financial crisis, foreign-participating ports are more efficient

than state-owned ones, but the differences disappear after crisis. The results indicate that, after the crisis, performance improves more for state-owned ports by 0.16 and is significantly larger than it is for ports with foreign ownership (the average efficiency improvement is only 0.07). We also observe that the differences in performance improvement for the two types of ports is 0.09 and significant. These preliminary comparisons support our hypotheses. Given that the results are based on a simple dichotomy (with or without foreign ownership), more elaborate results can be obtained using the continuous version of foreign ownership. Those results are reported in the following section.

Table 6. Basic *t*-test results

	Foreign ownership				Differences
	Yes		No		
	N	Mean	N	Mean	
Before crisis	89	0.33 (0.02)	97	0.26 (0.02)	0.07** (0.02)
After crisis	152	0.40 (0.01)	152	0.42 (0.02)	-0.02 (0.03)
Differences		**0.07***** **(0.01)**		**0.16***** **(0.03)**	**0.09**** **(0.04)**

Note: Standard errors are reported in parentheses. *p<0.10, **p<0.05, and ***p<0.001 (two-tailed test).

5.3 Multivariate Regression Analysis

Table 7 presents the OLS regression estimates of the effect of port performance on foreign ownership and other control variables during different stages. Models 1 and 3 set the benchmark

results for the pre- and post-crisis periods, respectively, by including all the control variables. The results show that GDP, inter-port competition, intra-port competition, firm size, and firm age all have significant influence on port performance.

Table 7. Regression results on DEA scores

Stage	Model 1	Model 2	Model 3	Model 4
	Before crisis	Before crisis	After crisis	After crisis
Const.	-0.871***	-0.903***	-1.282***	-1.26***
	(0.200)	(0.199)	(0.201)	(-6.21)
Foreign		0.077*		-0.096**
equity		(0.045)		(0.048)
GDP (Log)	0.106***	0.109***	0.119***	0.144***
	(0.020)	(0.020)	(0.019)	(0.020)
Inter-port	0.043	0.0426*	0.059**	0.141***
competition	(0.028)	(0.028)	(0.028)	(0.030)
Intra-port	0.013**	0.010	0.015***	0.018***
competition	(0.006)	(0.007)	(0.004)	(0.005)
Firm size	0.024***	0.022***	0.016**	0.018**
	(0.006)	(0.007)	(0.007)	(0.008)
Firm age	0.005**	0.004*	-0.004*	-0.003
	(0.002)	(0.003)	(0.002)	(0.002)
N	186	186	304	304
Adj R^2	0.273	0.305	0.246	0.257
Mean VIF	1.17	1.22	1.25	1.29

Notes: Robust standard errors are reported in parentheses. *p<0.10, **p<0.05, and ***p<0.001 (two-tailed test).

Model 2 tests Hypothesis 1 using terminal level data before the crisis. The coefficient of foreign ownership is positive (0.077), as predicted, and significant at the 10% level, proving that foreign ownership positively impacts port performance in terms of operational efficiency. Model

4 tested Hypothesis 2 using terminal level data after the crisis; a negative coefficient of foreign ownership (-0.096) at the 5% significance level is estimated. Hypothesis 2 is thus proved. We report estimated robust standard errors in Table 7 and below. Consistent estimations are provided when heteroscedasticity presents. Therefore, the results could mitigate concerns about cross-sectional and serial correlations of residuals from unbalanced panel data.

5.4 Robustness Test

To ensure the robustness of our results, we employ the truncated double bootstrapping procedures proposed by Simar and Wilson (2007, 2011), median regressions (Koenker, 2005) and the metafrontier analysis method (Chang and Tovar, 2017; O'Donnell et al., 2008) to run our regression model.

5.4.1 Truncated Double Bootstrapping Procedures

Table 8 shows the results from the regression model with truncated double bootstrapping. Following the procedure proposed by Simar and Wilson (2007), we use 1000 repetitions in bootstrapping. The results in Tables 7 and 8 do not have significant differences. Therefore, we can conclude that OLS regression is an appropriate method for the data analysis (Chernick, 2008).

Table 8. Regression results on DEA scores: with truncated double bootstrapping

Stage	Model 1	Model 2	Model 3	Model 4
	Before crisis	Before crisis	After crisis	After crisis
Const.	-1.247***	-1.273**	-1.517***	-1.447***
	(0.281)	(0.272)	(0.327)	(0.320)
Foreign ownership		0.097*		-0.134**
		(0.053)		(0.054)
GDP (Log)	0.138***	0.141***	0.164***	0.157***
	(0.027)	(0.026)	(0.030)	(0.030)
Inter-port	0.064*	0.062	0.146***	0.146***
competition	(0.039)	(0.038)	(0.035)	(0.034)
Intra-port	0.017**	0.012	0.022***	0.028***
competition	(0.008)	(0.008)	(0.007)	(0.007)
Firm size	0.027***	0.024***	0.018 *	0.018*
	(0.008)	(0.008)	(0.010)	(0.010)
Firm age	0.007**	0.005*	-0.005*	-0.003
	(0.003)	(0.003)	(0.003)	(0.003)
N	186	186	304	304
Wald chi2	61.34***	68.45***	74.66***	80.95***

Notes: Bootstrapped standard errors are reported in parentheses. The bootstrap procedure is based on 1000 replications. Sigma is reported truncated regressions. *p<0.10, **p<0.05, and ***p<0.001 (two-tailed test).

5.4.2 Median Regression

Table 9 provides results from median regressions as a special procedure of quantile regression proposed by Koenker (2005). The results are generally consistent with the OLS regression in Table 9. In Model 2, the coefficient of foreign ownership is also positive (0.053), as predicted, and significant at the 10% level. Additionally, in Model 4, a negative coefficient of foreign ownership (-0.130) at the 10% significance level is estimated. All these results support our hypotheses very well.

Table 9. Foreign ownership's effect on port performance during different stages: median regression

Stage	Model 1	Model 2	Model 3	Model 4
	Before crisis	Before crisis	After crisis	After crisis
Const.	-0.840***	-0.835***	-0.975**	-0.947**
	(0.284)	(0.304)	(0.372)	(0.382)
Foreign ownership		0.053*		-0.130*
		(0.069)		(0.070)
GDP (Log)	0.100***	0.100***	0.118***	0.113***
	(0.028)	(0.030)	(0.035)	(0.036)
Inter-port	0.027	0.032	0.116***	0.131***
competition	(0.040)	(0.042)	(0.041)	(0.042)
Intra-port	0.014*	0.009	0.022**	0.031***
competition	(0.009)	(0.011)	(0.008)	(0.009)
Firm size	0.037***	0.033***	0.009	0.002
	(0.009)	(0.010)	(0.012)	(0.012)
Firm age	0.006*	0.006*	-0.006**	-0.003
	(0.004)	(0.004)	(0.003)	(0.004)
N	186	186	304	304
Pseudo R2	0.198	0.202	0.181	0.191

Notes: Robust standard errors are reported in parentheses. *p<0.10, **p<0.05, and ***p<0.001 (two-tailed test).

5.4.3 Meta-Frontier Analysis

As our hypotheses implied, port terminals with and without foreign owner participation have fundamental differences. As a result, if we assume that all terminals are operated under the same production technology, the technical efficiency measurement may be erroneous. We follow the methodology proposed by O'Donnell et al. (2008) and Chang and Tovar (2017) to reexamine our hypotheses based on the metafrontier analysis. As in O'Donnell et al. (2008), we define a common metafrontier as the boundary of an unrestricted technology set, which could be accessed by all

505 firms. However, the restrictions derived from a lack of economic infrastructure, and/or other
506 characteristics of the production environment, could cause some firms to have no access to the
507 unrestricted technology, forcing them to use restricted technology sets. In this paper, our theory
508 provides a possible technological difference among terminals, so we divide them into two classes:
509 terminals with and without foreign ownership. Therefore, port terminals in our sample operate
510 under distinct group frontiers but face a common potential metafrontier. As O'Donnell et al. (2008)
511 suggest, we link technical efficiency with respect to the group-specific frontier and the
512 metafrontier by a ratio of the two technical efficiencies, called the Technology Gap Ratio (*TGR*).
513 The *TGR* will be the dependent variable in our new regressions. The input and output variables are
514 the same as in our DEA-BCC process. Table 10 summarizes the yearly TGRs for port terminals
515 with and without foreign ownership. On average, the TGR is larger for terminals with and without
516 foreign ownership, but after 2009, state-owned ports have caught up rapidly, which is consistent
517 with our theory.

518 **Table 10.** Summary statistics for the technology gap ratio

Years	With foreign ownership				Without foreign ownership			
	N	Mean	STD	Median	N	Mean	STD	Median
All	241	0.58	0.28	0.62	249	0.55	0.24	0.57
2004	13	0.47	0.32	0.47	14	0.43	0.28	0.46
2005	15	0.52	0.29	0.53	16	0.38	0.25	0.29
2006	15	0.54	0.30	0.51	19	0.51	0.23	0.52
2007	21	0.58	0.26	0.65	20	0.51	0.23	0.51
2008	25	0.57	0.27	0.65	28	0.54	0.22	0.57
2009	24	0.55	0.27	0.60	28	0.55	0.23	0.57
2010	26	0.57	0.28	0.64	27	0.57	0.23	0.62

2011	27	0.61	0.27	0.67	24	0.61	0.24	0.69
2012	27	0.63	0.29	0.67	25	0.62	0.22	0.66
2013	25	0.62	0.29	0.62	24	0.63	0.22	0.68
2014	23	0.63	0.26	0.65	24	0.61	0.22	0.65

519 Table 11 reports the second-stage results about foreign ownership's effect on the Technology
520 Gap Ratio (*TGR*) during different stages. The results show that, after the crisis, the foreign
521 ownership variable is still significantly negative. This evidence is consistent with our hypotheses.
522 Before the crisis, we find some evidence to support our hypotheses, and the results show that
523 foreign ownership can improve efficiency, as the regression ecoefficiency of foreign ownership is
524 positive but not significant. It may be weak, but the sign of regression ecoefficiency is consistent
525 with our theory before the crisis. An examination of the results after the crisis, even using the
526 metafrontier framework, reveals that our main claims are still supported by the evidence.

527

528 **Table 11.** Foreign ownership's effect on the *TGR* during different stages: metafrontier analysis

Stage	Model 1	Model 2	Model 3	Model 4
	Before crisis	Before crisis	After crisis	After crisis
Const.	-0.98***	-0.99***	-0.76**	-0.72**
	(0.30)	(0.30)	(0.29)	(0.29)
Foreign ownership		0.03		-0.14**
		(0.06)		(0.05)
GDP (Log)	0.13***	0.14***	0.12***	0.11***
	(0.03)	(0.03)	(0.03)	(0.03)
Inter-port	0.03	0.03	0.10***	0.10***
competition	(0.04)	(0.04)	(0.03)	(0.03)
Intra-port	0.02*	0.02*	0.02***	0.03***
competition	(0.01)	(0.01)	'(0.01)	(0.01)
Firm size	0.05***	0.05***	0.03***	0.03***

	(0.01)	(0.01)	(0.01)	(0.01)
Firm age	0.06*	0.06	'-0.04*	(0.02)
	(0.03)	(0.04)	(0.02)	(0.02)
N	186	186	304	304
Adj R2	0.29	0.29	0.21	0.22

Notes: Robust standard errors are reported in parentheses. *p<0.10, **p<0.05, and ***p<0.001 (two-tailed test).

5.5 Discussion

The above findings support the hypotheses we develop from MFT and empirically confirm Baltazar and Brooks (2007) that port performance is a function (output) of the match (or fit) among various components in the context (Baltazar and Brooks, 2007).

Specifically, before the 2008 Financial Crisis, the external environment was comfortable and the rapid growth of the economy had created a large number of transportation demands, which led to an inadequate supply in the port industry. Due to the spillover effect, foreign investors generally possessing valuable resources—such as capital, operational management experience and advanced technologies—quickly improved local port performance by upgrading port infrastructure and technology, helping local staff to operate the port more efficiently. Therefore, foreign ownership fits this environment and leads to better port performance than was experienced by their counterparts, the local actors. This situation is most likely to occur during the initial stage of regional economic development.

The primary competitive advantage for local ports gradually shifts from operational efficiency to logistic services. This argument regarding the evolution of major competitive

advantages may also be evidenced by the widely accepted view of UNCTAD's four generations in port development, from being a cargo handler to becoming an integrated logistics center (UNCTAD, 1992, 1999). Instead of merely focusing on operational efficiency, ports are increasingly required to better understand their partners and facilitate cooperation within the supply chain. In our case, this trend is further enhanced by the fierce competition among Chinese container terminals when facing a dramatic decline in transport demand as a result of 2008 Financial Crisis. After the exogenous shock in 2008, foreign investors could hardly benefit from port performance as they did before the Financial Crisis. More importantly, their local counterparts who are embedded in the social and economic environment can better understand the needs of local customers and maintain good relationships with important local stakeholders such as banks, government agencies, etc. For example, all of the leading port companies who participated in the officially initiated demonstrated multimodal transportation project in 2016 are dominated by local actors. Therefore, compared with their competitors, these companies have priority in access to valuable recourse crucial for delivering their logistic service. In sum, foreign ownership does not fit the post 2008 external environment due to the liability of foreignness and results in poorer port performance.

6. Implication and Prospect

From the empirical findings, we can draw some managerial implications and policy suggestions for both port operators and public authorities to improve port performance. For decision-makers at ports, the managerial implications include the following:

a. Managers should consider port performance as a result of the fit between the structure and the environment. Therefore, port managers are required to constantly pay attention to not only operational efficiency but also external environmental change, considering that the core assets and capabilities contributing to current successes do not necessarily secure a firm's future success. On the contrary, they may even lead to failure under certain conditions, such as foreign ownership in our case.

b. Another important implication for managers stems from our research conclusion that local ownership may benefit port performance, given certain external environmental conditions, due to their better understanding of local demand or local advantage. We suggest port managers address and solve local issues by using innovations or a combination of innovations stemming from technology, management or business models. Managers must not only address customer demands but must also place themselves in their customers' position to solve customized logistics issues. Duplicating successful patterns from ports in other countries may be unwise because, when customer demand is localized, local port managers better understand their customers' specific needs.

585 Our study also enlightened governments and local authorities that—since foreign
586 participation does not always benefit port performance, and its spillover effect will be gradually
587 replaced by the liability of foreignness with the development of the local industry—the focus of
588 public policy in the port industry should center not merely on attracting foreign investment. An
589 alternative strategy for governments and local authorities is to focus on the promotion of those
590 local enterprises who learn from their foreign counterparts and engage in local innovation by
591 combining 'foreign knowledge' and local demand.

592 For future research, we encourage scholars to test the theory in other settings or by introducing
593 variables other than ownership, such as channels for various resources and knowledge, social
594 embedded status, etc. These strategies allow us to further check the generalization of MFT.
595 Furthermore, we find strategy information at the terminal-level—such as R&D per employee (Hill
596 and Snell, 1988), operation details (McGee et al., 1995) and finance-related activities (Daske et al.,
597 2012), etc.—is extremely hard to capture due to the limited data disclosed in the container terminal
598 industry. Therefore, our research focused on only one dimension in MFT. Future research is also
599 highly encouraged to test the validity of strategy-related dimensions in MFT—such as strategy-
600 environment-fit, structure-strategy-fit or even structure-strategy-environment-fit—and their
601 impact on port performance. One practical approach is to use the survey method to obtain strategy-
602 related information (Katsikeas et al., 2006) together with cross-sectional data at the same level.

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