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Impact of Ports' Diversification-Driven Industrial Transformation on Operating Performance: Regulatory Effect of Port Cities' Urban Economic Development Level

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Abstract: Diversification-driven industrial transformation (DIT) has become a strategy for port enterprises dealing with the dual impacts of slowing economic growth and pressure from domestic competitors. Considering the interactive relationship between ports and port cities, the subjects of this study were publicly listed port-related enterprises in China and corresponding port cities. The main and regulatory effects were used to test and analyze the impact of port enterprises' DIT and port cities' urban economic development (UED) level on three aspects of enterprises' operating performance: profitability, operating capacity, and development capability. The study found that the relationship between DIT and operating capacity is nonlinear and shaped like an inverted U, and exhibits an increasing negative impact on profitability and development capability. The UED level promotes those two aspects of port enterprises, has minimal impact on operating capacity, and has a positive regulatory effect on the relationship between port enterprises' DIT and operating performance. The empirical test results can provide decision-making basis for port enterprises to formulate diversified transformation strategy reasonably and achieve performance improvement, which is conducive to promoting the interactive development and integration of port city in China.

Keywords: urban economic development level; port enterprises; industrial transformation; operating performance; regulatory effect

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1. Introduction

Guided by the country's "Great Maritime Power" strategy and "Belt and Road Initiative", China's ports and maritime shipping play an important role as the main carriers of trade goods. However, a combination of factors—sustained slowing of global economic growth, the spread of trade protectionism, a long-term downturn in international shipping, and negative growth of China's imports and exports—have caused the country's port industry to exhibit overcapacity, resource mismatch, and lag in core competitiveness [1]. Some Chinese port enterprises have chosen diversification-driven industrial transformation (DIT) to deal with the impact of these unfavorable factors, and have scored some initial success. For example, at this stage, Shanghai Port has formed a port logistics industry chain, including terminal loading and unloading, warehousing and storage, shipping, land transportation, and agency services. Many port companies such as Qingdao Port, Tangshan Port and Lianyungang Port have successfully transformed into the multimodal logistics industry while planting the main business of the terminal. Over time, enterprises in the port industry have arrived at the consensus that it is necessary to transform and upgrade their industrial structure and achieve sustainable development.

The development of a port is closely related to the economy of its hinterland, while the urban economic development (UED) model and level of the corresponding port city can generate substantial transportation demand for the port [2]. Clark et al. [3] found that ports are key to creating comparative advantage in their hinterland cities. According to the location theory, efficient ports bring good market and economic benefits to the city by helping its location sustainability [4]. The transport connection between ports helps to improve port service efficiency and limit distance impedance, which has a significant promoting effect on port hinterland economy [5]. The relationship between a port and its port city changes between early and mature stages of development: the port and port-oriented industries are the original development foci that drive the economic development of the port city; subsequently, the port city becomes the focus, with the transformation of its urban industrial structure driving the port's economic transformation. Interactive development and integration of a port and its port city have since become the development paradigm for modern ports and port cities. The latter's UED level, policy mechanisms, and business environment provide development support for and affect the future development direction of the former.

Ports play an important role in the global supply chain through efficient logistics operations, and each port enterprise aims to increase economic value added through its unique competitive advantage [6]. Especially under the pressure of global competition, port authorities are looking for ways to improve their operational performance, which is an important indicator of the effectiveness of the activities the enterprises perform [7]. Scholars have conducted extensive research on the impact of DIT strategies on business performance, but have arrived at dissimilar conclusions. This indicates that there is a complex relationship between a port's DIT and its operating performance. Studies on port–port city relationships have proven that coordination between the two entities is conducive to achieving positive outcomes for both. However, to date, few scholars have analyzed the impact of port enterprises' DIT on their operating performance from the perspective of port–port city relationships. As an important external environmental factor, the UED level of port cities can provide essential synergy for port enterprises that implement DIT strategies to improve performance.

After taking into consideration the data acquisition process and interactive relationship between ports and port cities, China's listed port-related enterprises and their corresponding port cities were selected as the research subjects. The aim was to examine the relationship between the port cities' UED level, ports' DIT, and port enterprises' operating performance from the perspective of external regulation and internal transformation. The research results confirmed that the UED level of the port city plays a supporting role in the process of port enterprises implementing DIT, and helps improve these enterprises' operating performance. Empirical test results can help port enterprises comprehensively consider their internal operating characteristics and external economic environment. This will aid their decision-making regarding the rational formulation of DIT strategies to improve performance, which in turn will support the interactive development and integration of China's ports and port cities.

The division of this paper is as follows. In Section 2, we make theoretical analysis and research hypotheses on the relationship between port enterprises' DIT and business performance, and the moderating effect of port cities' UED on the relationship. Section 3 is the research design, which mainly introduces the data source, variable measurement and model construction. Then, the results of the empirical test on the panel data of China's listed port enterprises are presented in Section 4, followed by the conclusions and discussion in Section 5.

2. Literature Review and Research Hypotheses

The main DIT-related theories include the resource-based, industrial organization, principal agent, transaction cost, institutional, and internal capital market theories. After taking into account the attributes of state-owned enterprises, which port enterprises are, and the characteristics of asset-heavy industries, we selected the resource-based theory and institutional explanation as the theoretical supports for this study. The resource-based theory emphasizes the importance of resources in the field of strategic management [8], and proposes that an enterprise's competitive advantage is derived from its internal resources and its own capabilities. These resources and capabilities are unique, difficult to imitate, and non-reproducible, and they help improve an enterprise's long-term operating performance. Under the resource-based perspective, DIT involves the enterprise's strategic goal of deploying its own resources in the most efficient manner [9].

The institutional explanation of DIT is particularly applicable to countries and regions with transitional economies. It emphasizes the impact of differences in institutional background on the DIT and operating performance of enterprises [10]. In transitional economies, the market mechanism is less important than the non-market mechanism. To operate, enterprises continue to rely heavily on non-market systems, such as government intervention or social networks, to obtain important resources such as capital and human resources [11]. As such, enterprises' DIT and operating performance are affected by the external institutional environment.

Existing literature shows that the impact of DIT strategies on operating performance may produce differing outcomes. An appropriate DIT level helps enterprises to diversify business risk, stabilize earnings [12], and improve financial capabilities [13]. DIT can also optimize resource allocation, increase operating efficiency, create an internal capital market, reduce financing risks, and improve the efficiency of internal capital utilization [14,15]. These lead to economies of scale and reduction in unit output costs [16], which helps expand business scope, as well as improving competitiveness and market position [17]. However, if an enterprise's resources and management capabilities cannot provide protection long enough for its new business sectors to gain competitive advantage, then those sectors will eventually be eliminated by competition. In this scenario, the enterprise's continued DIT may generate only short-term benefits. Having too many new business sectors also diverts a substantial share of limited resources, thus weakening the operating performance of the main business. Many resources are wasted if the new business sectors are poorly managed and inefficient, which increases the enterprise's cost of shared resources and reduces the overall efficiency of its resource allocation [18]. A serious internal agency problem arises when there is a mismatch between the enterprise's level of internal governance and the capital market's efficiency of operations on one hand, and excessive investments on the other hand [19,20], thus reducing the enterprise's operating performance.

Some scholars argue that no relationship exists between an enterprise's DIT and its operating performance [21,22]. However, other research shows that the relationship between the two is either that of a discount effect [23–25], a premium effect [26–28], or a complicated situation in which the two effects alternate [29–31]. Based on the conclusions from prior research and the practical actions taken by China's port enterprises toward DIT in recent years, it is evident that DIT strategies can help those enterprises grow their business. However, after comprehensively considering the negative impacts that DIT may cause, the approach adopted in this study was to regard the impacts from different DIT-related aspects of operating performance as unlikely to be simple linear relationships.

Considering the relationship that port construction has with national socioeconomic development and the particularity of port enterprises' business operations, their performance can be measured using multiple aspects, including profitability, operating capacity, and development capability. This led to Hypothesis 1 regarding DIT's impact on different aspects of operating performance:

H_{1a}: *There is an inverted U-shaped relationship between port enterprises' DIT and profitability.*

H_{1b}: *There is an inverted U-shaped relationship between port enterprises' DIT and operating capacity.*

H_{1c}: *There is an inverted U-shaped relationship between port enterprises' DIT and development capability.*

There are many Chinese and overseas studies on the relationship between ports and port cities' UED level. Si [32] found a significant correlation between port infrastructure and port cities' economy, with infrastructure construction having a role in promoting the latter's economic development. Zhao et al. [33] pointed out that although ports are the driving force behind the economic development of port cities, the competitiveness of such cities depends more on cities' own characteristics. Cong et al. [34] examined the interaction between a port's throughput and the economic indicators of its port city, and found that the former has a positive impact on the latter's GDP, which has synchronous growth with the value added by the port's secondary industries.

Scholars have shown a dynamic linkage between a port and the development of its port city. Using a port–port city relationship measurement model, Guo et al. [35] and Guo et al. [36] classified coastal ports into three types: port-driven, port–port city interaction, and urbanization-driven. They also highlighted that the port–port city relationship undergoes dynamic developments. Akhavan [37] used Dubai as a case study for research and described the dynamic development of Dubai's port city, showing a mutually beneficial relationship between the port and the port city. The sustainable development of ports and port cities has also attracted the attention of scholars. Boulos [38] believed that the key to maintaining balanced development between ports and port cities is for cities to provide the requisite infrastructure and services for the development of ports. On this basis, a model and framework to develop port–port city integration can be constructed to support sustainable development.

Xiao et al. [39] pointed out that the expansion and modernization of ports are inseparable from the development of port cities. As port developments have important impacts on the urban environment, the port–port city relationship must be fully considered to ensure the sustainable development of both. Zhao et al. [40] built a nonlinear model for the green growth of port cities, with the basic conditions being the coordinated growth of the port city's GDP and the port's throughput capacity.

These studies demonstrate the close connection between ports and port cities, and the mutual influence of both. A port's vitality drives the port city's economic development, while a port city provides the port with strong support for development. The port is the import and export locus for the urban logistics subsystem. The port city's industrial and economic development create transportation demand for the port and induce an increase in the port's production capacity. A rational economic structure for the port and port city, as well as highly developed trade and logistics capability in the port city, increase the port's comprehensive competitiveness [41]. When the port city's industrial structure is upgraded, its consumption structure rationalized, and its resource allocation optimized, the market space for port enterprises will expand. This in turn provides port enterprises with room for trial and error during the transformation and upgrading process [42]. A port city is the closest and most essential hinterland of a port. When port enterprises face the issues of industrial upgrading and industrial transformation, their profitability, operating capacity, and development capability are largely dependent on the economic development of the corresponding port city. This is especially true for export-oriented economies.

Based on the above, Hypothesis 2 was proposed.

$\mathbf{H_{2a}}$: *Port cities' UED level promotes port enterprises' profitability.*

$\mathbf{H_{2b}}$: *Port cities' UED level promotes port enterprises' operating capacity.*

$\mathbf{H_{2c}}$: *Port cities' UED level promotes port enterprises' development capability.*

DIT has become one of the main strategic choices for port enterprises coping with an unfavorable economic situation and industrial environment. As port cities transform and upgrade their industrial structure, port enterprises have responded with DIT, and ports have gradually evolved from performing a single function to performing multiple functions. Port cities that are highly developed economically provide associated ports with the following: a good business environment for transformation and upgrading;

increased investment in the freight collection, distribution, and transportation system, and construction of basic infrastructure; relevant policy support and adequate high-quality factors of production. These in turn drive the development of port enterprises' dependent industries, such as loading and unloading, comprehensive logistics, and port management, as well as that of the related industries of commodity trading, multimodal transportation, and financial services. As a result, there are positive interactions between a port and the port city, which enable capital, information, business, and logistics flows, creating synergies. Therefore, port cities' UED level has a role in promoting port enterprises' DIT and improving their operating performance. Based on this analysis, this study proposed Hypothesis 3.

H_3: *Port cities' UED level promotes port enterprises' implementation of DIT and improvement of operating performance.*

The port enterprise–city relationship and the research model of this study are illustrated in Figures 1 and 2, respectively.

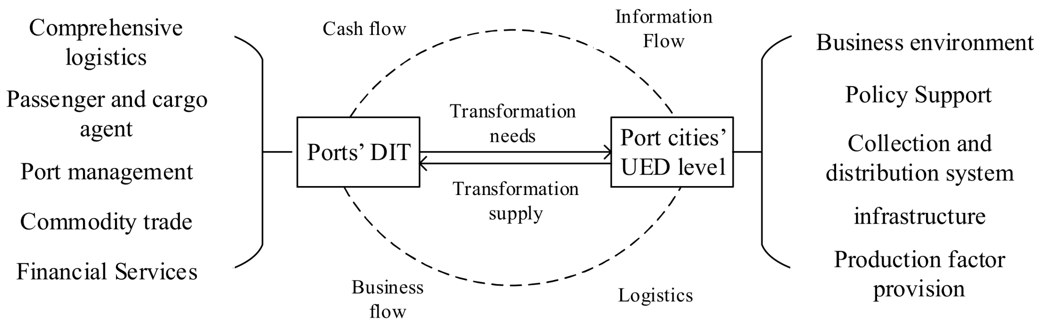

Figure 1. Port enterprise–city relationship.

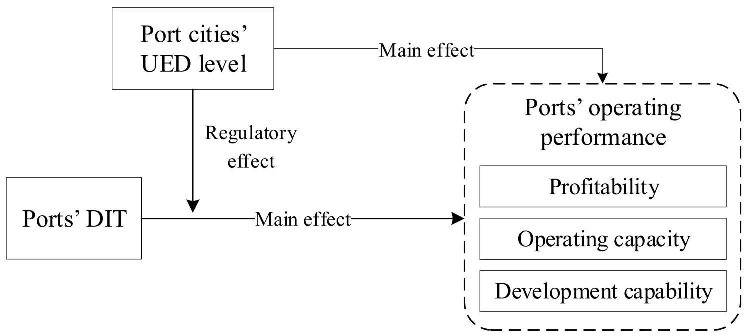

Figure 2. Research model.

3. Research Design

3.1. Sample Selection and Data Sources

With data availability as the consideration, a group of publicly listed port enterprises was selected as the research subject. There were originally 20 port enterprises in the group, but the Wanjiang Logistics Group was subsequently removed because after its subsidiary Huaikuang Logistics was suspected of financial fraud in 2014, it underwent a major asset reorganization during the latter part of the study period and was renamed the Huaihe Energy Group. With the alteration of the enterprise's original main business and development direction, the accuracy and reliability of the research data and results would have been compromised. With this removal, there were 19 listed port-related enterprises. Their 2012–2019 data were obtained from GTA Education Tech Ltd.'s (Shenzhen, China) CSMAR database for analysis. The data were supplemented by information from Sina Finance and the various enterprises' financial reports. With both Yantian and China Merchants Ports located in Shenzhen, the 19 listed enterprises corresponded to a total of 18 port cities. Data for the cities for 2011–2018 was mainly acquired from the EPS database, and supplemented by information from the China Economic Information Network (https://ceidata.cei.cn/, accessed on 22 March 2022) and the various cities' statistical yearbooks.

The 19 listed port-related enterprises are: (i) Yantian Port Holdings Co., Ltd. (Shenzhen, China); (ii) Zhuhai Port Holdings Group Co., Ltd. (Zhuhai, China); (iii) Beibu Gulf Port Co., Ltd. (Nanning, China); (iv) Xiamen Port Holdings Group Co., Ltd. (Xiamen, China); (v) China Merchants Port Holdings Co., Ltd. (originally Shenzhen Chiwan Wharf Holdings but renamed on Dec 26, 2018) (Shenzhen, China); (vi) Nanjing Port Group Co., Ltd. (Nanjing, China); (vii) Rizhao Port Co., Ltd. (Rizhao, China); (viii) Shanghai International Port Group Co., Ltd. (Shanghai, China); (ix) Jinzhou Port Co., Ltd. (Jinzhou, China); (x) Chongqing Gangjiu Co., Ltd. (Chongqing, China); (xi) Yingkou Port Group Co., Ltd. (Yingkou, China); (xii) Tianjin Port Group Co., Ltd. (Tianjin, China); (xiii) Tangshan Port Group Co., Ltd. (Tangshan, China); (xiv) Lianyun Port Co., Ltd. (Lianyungang, China); (xv) Ningbo Port Group Co., Ltd. (Ningbo, China); (xvi) Guangzhou Port Group Co., Ltd. (Guangzhou, China); (xvii) Qingdao Port International Co., Ltd. (Qingdao, China); (xviii) Qinhuangdao Port Co., Ltd. (Qinhuangdao, China); (xix) Dalian Port Co., Ltd. (Dalian, China).

The 18 port cities are: (i) Shenzhen, (ii) Zhuhai, (iii) Nanning, (iv) Xiamen, (v) Nanjing, (vi) Rizhao, (vii) Shanghai, (viii) Jinzhou, (ix) Chongqing, (x) Yingkou, (xi) Tianjin, (xii) Tangshan, (xiii) Lianyungang, (xiv) Ningbo, (xv) Guangzhou, (xvi) Qingdao, (xvii) Qinhuangdao, and (xviii) Dalian.

Considering the general problem of information asymmetry between enterprises and governments, and the delay in the impact of the external economic environment on enterprises' operations, there was a one-period lag in the data used for the variable of port cities' UED level.

3.2. Measurement of Variables

3.2.1. Indicators for Measurement of DIT

Presently, the most widely used indicators in China and overseas for measurement of DIT are the Herfindahl index (HI) [43,44] and entropy index (EI) [45–47]. The HI reflects the proportion of each business unit's sales to the enterprise's total sales, and is used to measure the enterprise's DIT level. It is simple and easy to calculate, and the results are scientifically valid. The disadvantage in using the HI is its inability to reflect the relatedness among the various business sectors. Unlike the HI, the EI has separability, which better measures an enterprise's related DIT and unrelated DIT. The disadvantage in using the EI is the large amount of data involved, which makes calculation complicated. Ultimately, the HI was selected to measure the DIT level of China's port enterprises in this study because when examining the post-DIT operating performance of listed port-related enterprises, it was not necessary to segregate the effects of related DIT and unrelated DIT.

The value of the HI is between 0 and 1; the larger the index value, the higher the DIT level. The equation for calculation is:

$$HI = 1 - \sum_{i=1}^{n} {P_i}^2 \tag{1}$$

where n represents the total number of business sectors encompassed by DIT, P_i represents the proportion that each business sector's sales revenue contributes to the enterprise's total sales revenue, and HI is the Herfindahl index, with the value range being 0–1. The closer the HI is to 1, the higher the enterprise's DIT level; when the HI is 0, the enterprise's operations are confined to loading, unloading, and transloading cargo.

3.2.2. Indicators for Evaluating the UED Level of Port Cities

The relevant data were collected and organized in this study in accordance with the measurement method for level of economic development proposed by Wei et al. [48], and based on the connotations of UED. The method comprises four criteria: (i) economic scale, (ii) benefit level, (iii) economic structure, and (iv) degree of opening up. The UED level of the 18 port cities from 2011–2018 was also evaluated using the relevant data for eight indicators: (i) regional GDP, (ii) total social investments in fixed assets, (iii) GDP per capita, (iv) average wage of employees, (v) proportion of the secondary industry's output value, (vi) proportion of the tertiary industry's output value, (vii) total value of imports and exports, and (viii) actual amount of foreign capital utilized (Table 1).

Table 1. Indicator system for evaluating port cities' UED level.

Target Layer	Criterion Layer	Indicator Layer		X
		Indicator	Unit	
UED level	Economic scale	Regional GDP	100 million RMB	X_1
		Total social investments in fixed assets	100 million RMB	X_2
	Benefit level	GDP per capita	RMB	X_3
		Average wage of employees	RMB	X_4
	Economic structure	Proportion of the secondary industry's output value	%	X_5
		Proportion of the tertiary industry's output value	%	X_6
	Degree of opening up	Total value of imports and exports	100 million USD	X_7
		Actual amount of foreign capital utilized	100 million USD	X_8

Note: "Total value of imports and exports" is a sum of values of imports and exports.

To ensure objectivity of the comprehensive indicators for the port cities' UED level, weights were objectively assigned to the indicators using the entropy weighting method in the comprehensive evaluation by Xie et al. [49]. The weights were used to calculate the weighted sum of all the indicators to arrive at the comprehensive evaluation indicator for port cities' UED level. The steps in the calculation are stated below.

First, the original data of each indicator was subjected to dimensionless processing:

$$S_{ij} = \frac{x_{ij} - x_{min}}{x_{max} - x_{min}} \tag{2}$$

where x_{ij}, x_{min}, and x_{max} represent the original, minimum, and maximum value of an indicator, respectively. The dimensionless data were subjected to overall translation to eliminate values of zero or less, $S_{ij} = S_{ij} + \alpha$, where the value of α is 0.001.

Next, the contribution of the jth indicator to the ith port city under that indicator was calculated:

$$P_{ij} = \frac{S_{ij}}{\sum_{i=1}^{n} S_{ij}},\ i = 1,\ 2,\ \ldots,\ n \tag{3}$$

where n is the number of port cities, with the value being 18.

The entropy of the jth indicator was then calculated:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} P_{ij} \ln P_{ij},\ 0 \leq e_j \leq 1 \tag{4}$$

The coefficient of difference of the jth indicator, $g_j = 1 - e_j$, was substituted into the equation below to ascertain the weight W_j of the various evaluation indicators. The comprehensive score for each port city's UED level was then calculated:

$$W_j = \frac{g_j}{\sum_{j=1}^{m} g_j},\ j = 1,\ 2,\ \ldots,\ m \tag{5}$$

$$S = \sum_{j=1}^{m} W_j P_{ij} \tag{6}$$

where m is the number of evaluation indicators, with the value being 8.

The average value of each indicator for the port cities from 2011 to 2018 was used for entropy weighting to ensure longitudinal and cross-sectional data comparability. After calculation, the weights corresponding to the evaluation indicators X_1–X_8 for the port cities' UED level were 0.167, 0.106, 0.050, 0.050, 0.074, 0.139, 0.200, and 0.214, respectively. In order to eliminate the influence of price factors, all kinds of monetary volume indicators were adjusted to 2010 constant prices.

Figure 3 shows the average UED levels of 18 relevant port cities from 2011 to 2018. It can be seen that the UED levels of Shanghai, Shenzhen and Tianjin are among the top three cities, corresponding to the listed port enterprises with excellent performance in Shanghai International Port Group Co., Ltd. (Shanghai, Chian), Beibu Gulf Port Co., Ltd. (Nanning, China) and Tianjin Port Group Co., Ltd. (Tianjin, China). However, Jinzhou Port Co., Ltd. (Jinzhou, China) and Yingkou Port Group Co., Ltd. (Yingkou, China), both of which belong to Liaoning Province, are located in port cities with low UED levels, and the operating performance of the two enterprises is relatively poor. According to this, it can be preliminarily inferred that the operating conditions of port enterprises may be correlated with the economic development level of the port cities where they are located.

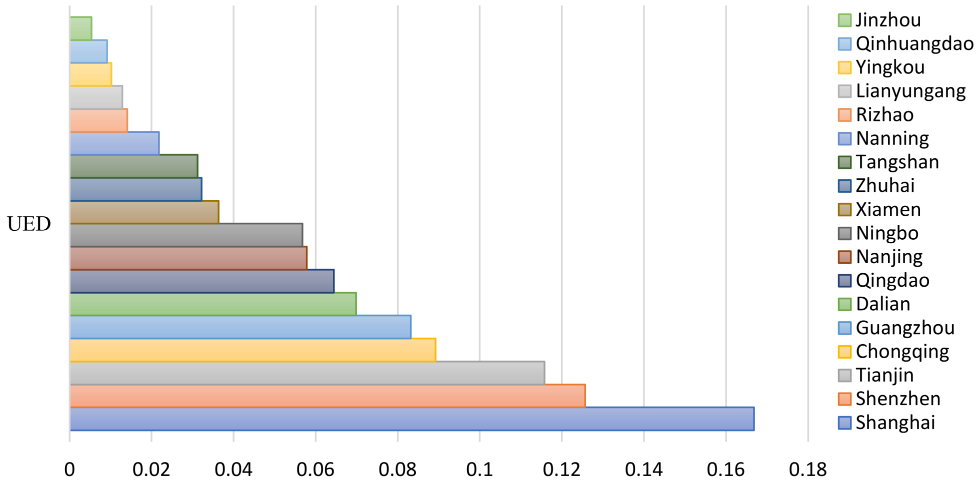

Figure 3. 2011–2018 average for port city's UED.

3.2.3. Indicators for Measuring the Operating Performance of Port Enterprises

Drawing on existing research, operating performance was set as the dependent variable, and indicators were selected from three aspects: profitability, operating capacity, and development capability. Return on total and net assets were the indicators reflecting profitability; turnover on total and net assets were for operating capacity; sustainable growth rate reflected development capability. Among them, sustainable growth rate is the maximum growth rate of the company's sales that can be achieved without issuing additional new shares and maintaining the current operating efficiency and financial policies.

3.2.4. Control Variables

In this study we controlled for the impact of the following variables on port enterprises' operating performance: enterprise size, asset–liability ratio, ratio of shares held by the largest shareholder, years of enterprise's establishment, and year effect. The definitions of and symbols for the specific variables are shown in Table 2.

3.3. Model Building

Following the hierarchical regression method for regulatory effects by Wen et al. [50] and Fang et al. [51], the indicators for the three aspects of port enterprises' operating performance were taken as the explained variables. The explanatory variables were the HI, the square term of HI, the comprehensive indicator of port cities' UED, the interaction term between HI and UED and the interaction term between the square of HI and UED. After considering the impact of the control variables, Model 1 was constructed to test Hypotheses 1, and Model 2 to test Hypothesis 2 and 3. The two models are shown using Equations (7) and (8), respectively:

$$performance_{i,t} = \beta_0 + \beta_1 hi_{i,t} + \beta_2 hi^2_{i,t} + \beta_3 asset_{i,t} + \beta_4 lev_{i,t} + \beta_5 share_{i,t} + \beta_6 age_{i,t} + year\ effect + \varepsilon_{i,t} \quad (7)$$

$$\begin{aligned} performance_{i,t} &= \beta_0 + \beta_1 hi_{i,t} + \beta_2 hi^2_{i,t} + \beta_3 ued_{i,t-1} + \beta_4 hi_{i,t} \times ued_{i,t-1} + \beta_5 hi^2_{i,t} \times ued_{i,t-1} + \beta_6 asset_{i,t} \\ &\quad + \beta_7 lev_{i,t} + \beta_8 share_{i,t} + \beta_9 age_{i,t} + year\ effect + \varepsilon_{i,t} \end{aligned} \quad (8)$$

where *performance* represents the indicators for the enterprises' operating performance, *hi* represents the DIT level, hi^2 represents the square of *hi*, *ued* represents the UED level, *i* stands for the listed port-related enterprises, and *t* stands for the year.

Table 2. List of control variables.

Type of Variable	Name of Variable	Symbol	Definition
Dependent	Return on total assets	*roa*	Net profit/Average total assets × 100%
	Return on net assets	*roe*	Net profit/Average total shareholders' equity × 100%
	Turnover of total assets	*tat*	Net operating income/Average total assets
	Turnover of net assets	*et*	Net operating income/Average shareholders' equity
	Sustainable growth rate	*sgr*	Return on net assets × Earnings retention rate/ (1 − Return on net assets × Earnings retention rate)
Independent	HI	*hi*	$1 - \sum$(proportion of each segment's sales revenue to the enterprise's total sales revenue)^2
Regulatory	UED	*ued*	$\sum$(Various economic evaluation indicators × Weight from entropy calculation)
Control	Enterprise size	*asset*	Expressed by the natural logarithm of the total assets at end of period: $ln(ASSET)$
	Asset–liability ratio	*lev*	Total liabilities/Total assets × 100%
	Ratio of shares held by the largest shareholder	*share*	Number of shares held by the largest shareholder/Total number of shares held by the listed enterprise
	Years of establishment	*age*	Expressed by the logarithm of the years of enterprise's establishment: $ln(AGE + 1)$
	Year effect	*year*	Sampling years for the enterprises were 2012–2019. A total of 8 years and 7 dummy variables were included

Note: Earnings retention rate is the ratio of a company's after-tax earnings to after-tax earnings after deducting the difference between the cash dividend payable.

4. Results of Empirical Analysis

4.1. Descriptive Analysis

After analyzing the descriptive statistics, the results show that for the indicators of the sample enterprises' financial performance (return on total and net assets, turnover of total and net assets, and sustainable growth rate), the standard deviation and mean did not differ much. However, there was a large difference between the minimum and maximum values of each indicator. This shows that the profitability, operating capacity, and development capability of China's listed port-related companies are uneven at present. The port cities' UED level also varied greatly (Table 3).

The average DIT level of the sample enterprises was approximately 0.39, indicating that the overall DIT of China's listed port-related enterprises was not high. Their operations remained largely dependent on the core business of loading and unloading goods at the terminals. For the control variables, the mean of the sample enterprises' assets–liabilities ratio was approximately 40.9%, with the capital structure at a relatively safe level. The average logarithm of asset size was 23.44, and the difference between the minimum and maximum values was only 5.01. This indicates that variations in the asset size of listed port-related enterprises were not large. Separately, a test for the variance expansion factors was carried out. None of the variance expansion factors exceeded 5, indicating that there was no multicollinearity between the variables.

Table 3. Descriptive statistics of the variables.

Variable	Observed Value	Mean	Standard Deviation	Minimum Value	Maximum Value
roa	145	0.045	0.026	0.001	0.100
roe	145	0.076	0.043	0.001	0.177
tat	145	0.349	0.325	0.003	1.772
et	145	0.660	0.731	0.0429	5.300
sgr	145	0.062	0.045	−0.020	0.228
hi	145	0.385	0.237	0	0.830
ued	145	0.059	0.048	0.003	0.176
lnasset	145	23.440	1.017	20.770	25.780
lev	145	0.409	0.111	0.075	0.722
share	145	0.517	0.165	0.154	0.795
age	145	2.745	0.488	0.693	3.466

4.2. Analysis of Regression Results

In general, mixed ordinary least squares (OLS), fixed effect (FE) model and random effect (RE) model can be used to estimate the panel data model. An Lagrange multiplier test (LM test), joint hypotheses test (F test) and Hausman test were performed to determine the model form. Table 4 test results show that the RE model is more effective than the mixed OLS model and the FE model. At the same time, in order to eliminate the influence of heteroscedasticity, the feasible generalized least square method (FGLS) is selected to test the model.

Table 4. LM test, F test and Hausman test results.

Test	Statistics	*p* Value
LM test	$\text{chibar}^2 = 128.66$	0.0000
F test	F = 10.50	0.0000
Hausman test	$\text{chi}^2 = 4.29$	0.9935

In order to avoid the problem of multicollinearity, the variables involved in cross-multiplication are centralized and tested by stata15.1 software. Using *roa, roe, tat, et and sgr* as explained variables, hierarchical regression analysis is conducted on the test model. For Model 1, regression was done between port enterprises' operating performance and the Herfindahl index (HI), and the square term of the HI. For Model 2, the interactive term for (a) the HI added to the regression result in the first step as the basis and port cities' UED level and (b) the square term of the HI and port cities' UED level, were regressed to test the main and regulatory effects of the target variable, respectively. Model 1 corresponds to formula (7), and Model 2 to formula (8). The specific regression results are shown in Table 5. It is worth noting that the indicator *L.ued* indicates the lagged one-period UED level, the same below.

Model 1 tested the main effect of DIT on port enterprises' operating performance. The results show that the regression coefficients for the indicators of the sample enterprises' operating performance on the square term of the HI was significantly negative at the 1% level. The rates of turnover of total and net assets corresponding to the coefficient of the HI's first-order term were significantly positive, and the peak of the corresponding statistical model was within the range of independent variables, with the value of HI ranging from 0 to 1. This indicates that there was an inverted U-shape relationship between DIT and the port enterprises' operational capabilities. In other words, although DIT could enhance port enterprises' operational capabilities, there would be a negative effect on port enterprises' operational capabilities when the DIT level was too high and reached a particular threshold. Thus, Hypothesis H_{1b} was confirmed.

Table 5. DIT, UED level, and operating performance of port enterprises.

Variable	*roa*		*roe*		*tat*		*et*		*sgr*	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
hi	−0.009	−0.015 *	−0.023 *	−0.032 **	0.367 ***	0.419 ***	0.521 ***	0.607 ***	−0.022 *	−0.029 **
	(0.007)	(0.008)	(0.013)	(0.014)	(0.065)	(0.068)	(0.139)	(0.153)	(0.012)	(0.013)
hi^2	−0.082 ***	−0.059 **	−0.158 ***	−0.145 ***	−0.982 ***	−1.026 ***	−1.642 ***	−1.741 ***	−0.211 ***	−0.211 ***
	(0.024)	(0.025)	(0.044)	(0.049)	(0.212)	(0.208)	(0.476)	(0.496)	(0.044)	(0.046)
L.ued		0.254 ***		0.436 ***		0.778 *		1.831 *		0.339 ***
		(0.052)		(0.099)		(0.450)		(0.950)		(0.095)
hi * *L.ued*		−0.734 ***		−0.859 **		−1.097		−3.664		−0.596 *
		(0.210)		(0.382)		(1.723)		(3.814)		(0.330)
hi^2 * *L.ued*		−2.098 **		−3.035		−22.165 **		−44.071 **		−2.826
		(0.943)		(1.889)		(8.821)		(19.045)		(1.834)
lnasset	0.009 ***	0.010 ***	0.015 ***	0.014 ***	−0.034 **	−0.034 **	−0.051	−0.047	0.009 ***	0.008 **
	(0.002)	(0.002)	(0.003)	(0.003)	(0.016)	(0.016)	(0.037)	(0.041)	(0.003)	(0.003)
lev	−0.119 ***	−0.071 ***	−0.053 **	0.006	0.039	0.133	1.151 ***	1.407 ***	−0.002	0.062 **
	(0.013)	(0.016)	(0.024)	(0.032)	(0.137)	(0.139)	(0.292)	(0.311)	(0.025)	(0.031)
share	−0.005	−0.009	−0.001	−0.009	0.282 ***	0.221 **	0.466 **	0.385 *	0.046 **	0.029
	(0.011)	(0.011)	(0.020)	(0.021)	(0.090)	(0.094)	(0.198)	(0.209)	(0.019)	(0.020)
age	−0.006 *	−0.011 ***	−0.014 **	−0.027 ***	0.159 ***	0.149 ***	0.182 ***	0.200 ***	−0.011	−0.028 ***
	(0.004)	(0.004)	(0.007)	(0.008)	(0.037)	(0.039)	(0.068)	(0.077)	(0.008)	(0.009)
year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Constant term	−0.077 *	−0.114 **	−0.181 **	−0.168 *	0.461	0.445	0.448	0.205	−0.129 *	−0.079
	(0.041)	(0.048)	(0.073)	(0.091)	(0.374)	(0.409)	(0.877)	(1.015)	(0.072)	(0.086)
Wald chi^2	224.04	274.87	91.62	121.42	52.00	83.38	38.92	55.63	59.03	77.44
Observed value	145	145	145	145	145	145	145	145	145	145

Note: *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively. The numbers stated within parentheses are the t-statistics.

The first-order coefficient of return on total assets corresponding to HI is not significant, and the first-order coefficient of return on net assets and sustainable growth rate corresponding to HI is significantly negative, indicating that the relationship between port enterprises' profitability and development capability, and their DIT level, was only reflected in the right half of the curve. Since DIT had a negative impact on the enterprises' profitability and development capability within the range of values, Hypotheses H_{1a} and H_{1c} could not be confirmed. In addition, the absolute value of the coefficients for the rate of turnover of total and net assets corresponding to hi and hi^2 was much greater than that for the rates of return on total and net assets, and sustainable growth rate. This indicates that the impact of DIT on port enterprises' operational capabilities was more significant.

In Model 2, the regression coefficients of port enterprises' rate of return on total and net assets, rate of turnover of total and net assets and sustainable growth rate to port cities' UED level were significantly positive. This indicates that port cities' UED level promoted port enterprises' profitability, operating capacity and development capability: the higher a port city's UED level, the more it improves the operating performance of port enterprises attached to it. Therefore, Hypotheses H_{2a}, H_{2b} and H_{2c} were confirmed.

After testing for the regulatory effect exerted by port cities' UED level, the results show that the interaction term between the square term of port enterprises' HI and port cities' UED level was significantly negative when total assets return, total and net assets turnover were the explanatory variables. At the same time, the coefficient of the square term of the HI was significantly negative, while the signs for the values of both were similar. Similarly, the interaction term between HI and UED was significantly negative when the explanatory variables were return on net assets and sustainable growth rate, with the same sign of the coefficient corresponding to HI. This indicates that port cities' UED level had a positive regulatory effect on the relationship between port enterprises' DIT and operating performance.

To further explain the regulatory effect, the relationship between the three aspects of port enterprises' DIT and operating performance under port cities' various UED levels were determined. As shown in Figure 4, when port cities' UED level is high, the inverted U-shaped curve between the port enterprises' DIT and operating capacity is steeper. In other words, a higher UED level strengthened the impact of port enterprises' DIT on their operating capacity. By the same principle, the UED level also had a positive regulating effect on the negative correlation between port enterprises' DIT and their profitability and development capability. Therefore, Hypothesis 3 was confirmed.

4.3. Robustness Test

On the one hand, considering that the influence of enterprise DIT on business performance may have a lag effect, this paper re-conducts model testing with explanatory variables lagging one period (Table A1), which can also solve the endogeneity problem to some extent. The regression results show that the results of this study did not change fundamentally. On the other hand, the time fixed effect model was used to replace FGLS for regression (Table A2). The aforementioned research conclusions did not vary when the estimation method was revised, and the results were consistent. Therefore, the relationship between China's listed port-related enterprises' DIT, port cities' UED level, and port enterprises' operating performance was deemed to be stable.

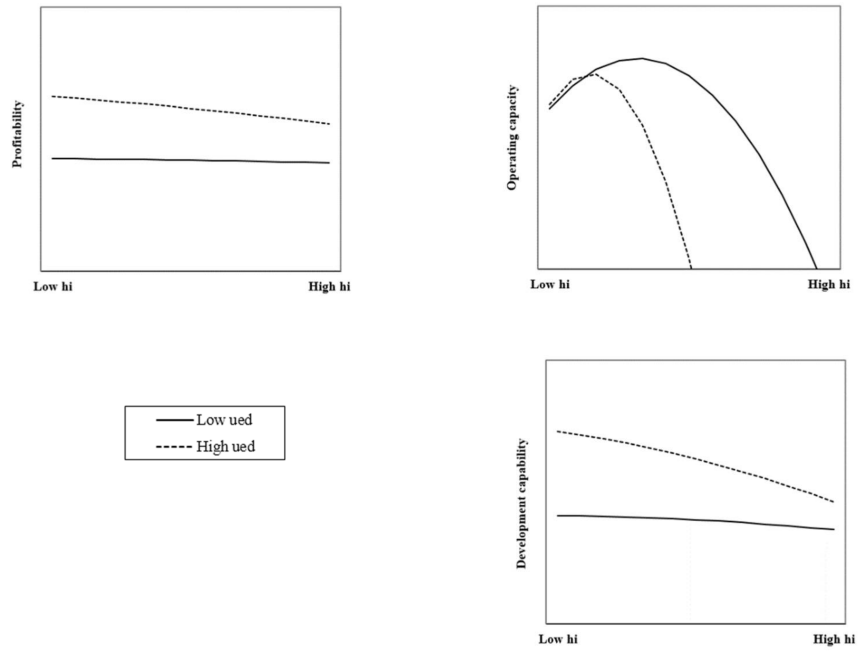

Figure 4. Regulatory effect of port cities' UED level.

5. Conclusions and Discussion

5.1. Main Conclusions and Policy Implications

In this study, the resource-based and institutional theories were used to examine the impact of port enterprises' DIT on their operating performance under the regulatory effect of port cities' UED level. The 2012–2019 data of 19 Chinese port-related listed enterprises and the 2011–2018 data of the 18 corresponding port cities were used as the basis for the corresponding empirical testing of three aspects related to the enterprises operating performance, namely profitability, operating capacity, and development capability. The test results for the main effect indicate that firstly, there was a nonlinear and inverted U-shaped relationship between port enterprises' DIT and their operating capacity. However, as DIT increases past a threshold level, it has an increasingly negative effect on profitability and development capability. This shows that an appropriate DIT level could effectively improve port enterprises' operating capacity, accelerate the rate of turnover of assets, and improve the efficiency of resource utilization.

It should be noted that for the business sectors introduced under DIT, time was required for them to mature and become profitable. During the period of analysis, the original core business of vessel loading and unloading was also affected by the overall economic situation, causing its contribution to decline significantly. This led to DIT having a negative impact on port enterprises' profitability and development capability during the initial stage of implementation: the higher the DIT level, the poorer the performance in terms of profitability and development capability.

Secondly, the conclusion after combining the test results that (a) port cities' UED level promoted port enterprises' profitability and development capability but (b) had little effect on their operating capacity, was that improvements to port enterprises' operating capacity were mainly dependent on the strategic transformation of internal businesses. This aspect was relatively less affected by the external environmental factor of port cities' UED level. However, port cities with a higher UED level would have a positive effect on port enterprises' profitability and development capability. Thus, port enterprises should harness the combined effects of an optimal level of strategic transformation of internal businesses and port cities' UED level in the ports' external environment. Doing so would enable them to improve their operating performance on the three dimensions of profitability, operating capacity, and development capability. The interactive development and integrated construction of ports and port cities would mutually complement the ports' internal transformation and the external environment to effectively improve ports' operating performance through the three aspects.

Thirdly, the test on the regulatory effect led to the conclusion that port cities' UED level had a positive regulatory effect on the relationship between port enterprises' DIT and their operating performance. Combining the conclusions of the test for the main effect, and considering the long-term effects that DIT has on profitability and development capability, port enterprises should pay extra attention to the regulatory effect exerted by port cities' UED level at the early stage of DIT. After a rational analysis of their operating results, enterprises can take effective measures to strengthen their diversified business sectors while maintaining a determined confidence in DIT. They can then achieve better profitability and potential for sustainable development through DIT and have positive interactions with the UED environment.

5.2. Limitations and Discussions

These empirical results on the one hand confirm that the impact of port enterprises' DIT on port operating performance is non-linear, rather than a single promotion or inhibition effect; on the other hand, they also show that port performance is inextricably linked to its hinterland economy. These results are of great significance for port enterprises to formulate business strategies and port cities to formulate economic policies.

Despite our efforts, there are some limitations in this study. This study may have overlooked more relevant factors, such as R&D innovation and human capital of port companies. In addition, the global economic environment is changing rapidly. There is a growing interest in sustainable production and consumption in ports, especially those in mature markets in developed regions. The sustainable development of port enterprises provides new motivation to the economic development of port cities [6]. The high energy consumption and pollution associated with port trade adversely affects the ecological environment while constraining the sustainable development of the port and its hinterland economy [52]. In order to solve this problem, the United Nations Climate Conference has proposed the "Green Port" initiative. With the advent of the fourth industrial revolution, the information industry has become the new engine driving the world's economic growth, and digital technology, while enabling green development [53], is also subtly reshaping the maritime industry and changing the way ports operate in the global transportation system. To remain competitive, ports need to actively implement port digitization and build "smart" ports [54].

Therefore, in the future, our research will pay more attention to the mechanism of green innovation, digital technology and other factors on the transformation and upgrading of port enterprises' DIT and port cities' UED, which can help the sustainable development of ports and their hinterlands.

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Appendix A

Table A1. Robustness test 1.

Variable	Model 1					Model 2				
	roa	*roe*	*tat*	*et*	*sgr*	*roa*	*roe*	*tat*	*et*	*sgr*
hi	−0.002	−0.007	0.521 ***	0.949 ***	−0.016	−0.006	−0.016	0.609 ***	1.046 ***	−0.020
	(−0.20)	(−0.46)	(4.47)	(4.55)	(−0.86)	(−0.56)	(−0.86)	(4.77)	(4.67)	(−0.96)
hi^2	−0.102 ***	−0.189 ***	−1.366 ***	−3.247 ***	−0.231 ***	−0.085 ***	−0.164 ***	−1.273 ***	−3.051 ***	−0.209 ***
	(−3.66)	(−3.51)	(−3.66)	(−4.04)	(−4.00)	(−2.73)	(−2.90)	(−3.30)	(−3.67)	(−3.68)
L.ued						0.251 ***	0.422 ***	0.807	2.685 **	0.392 ***
						(4.30)	(3.73)	(1.28)	(2.28)	(3.41)
*hi * L.ued*						−0.908 ***	−1.436 ***	−5.429 **	−12.360 **	−1.345 ***
						(−3.13)	(−2.84)	(−1.98)	(−2.43)	(−3.12)
hi^2 ** L.ued*						−3.087 **	−4.745 **	−32.088 ***	−63.258 ***	−5.177 **
						(−2.44)	(−2.07)	(−2.85)	(−3.09)	(−2.22)
year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Control variables	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Constant term	−0.033	−0.132	1.197 **	2.707 **	−0.050	−0.084	−0.205	0.595	1.645	−0.125
	(−0.61)	(−1.37)	(2.04)	(2.34)	(−0.55)	(−1.17)	(−1.58)	(0.92)	(1.23)	(−1.18)
Observed value	145	145	145	145	145	145	145	145	145	145
Adjusted R^2	0.442	0.299	0.336	0.409	0.306	0.480	0.320	0.275	0.353	0.297
F-value	13.90 ***	5.799 ***	3.084 ***	3.311 ***	3.664 ***	14.17 ***	6.750 ***	2.886 ***	2.830 ***	4.781 ***

Note: *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively. The numbers stated within parentheses are the t-statistics.

Table A2. Robustness test 2.

Variable	Model 1					Model 2				
	roa	*roe*	*tat*	*et*	*sgr*	*roa*	*roe*	*tat*	*et*	*sgr*
L.hi	−0.002	−0.004	0.386 ***	0.609 ***	0.009	−0.012	−0.016	0.437 ***	0.691 ***	0.002
	(0.007)	(0.014)	(0.071)	(0.143)	(0.014)	(0.009)	(0.016)	(0.072)	(0.147)	(0.015)
$L.hi^2$	−0.088 ***	−0.156 ***	−0.701 ***	−1.270 ***	−0.178 ***	−0.076 ***	−0.167 ***	−0.794 ***	−1.339 ***	−0.171 ***
	(0.025)	(0.049)	(0.227)	(0.453)	(0.052)	(0.028)	(0.054)	(0.226)	(0.474)	(0.054)
L.ued						0.239 ***	0.410 ***	0.799 *	1.634 *	0.331 ***
						(0.053)	(0.103)	(0.466)	(0.954)	(0.096)
*L.hi * L.ued*						−0.577 ***	−0.681 *	−0.964	−3.553	−0.648 *
						(0.224)	(0.399)	(1.826)	(3.676)	(0.343)
$L.hi^2$ ** L.ued*						−1.485	−2.283	−23.690 ***	−41.870 **	−2.670
						(0.957)	(1.941)	(9.061)	(18.427)	(1.925)
Control variables	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Constant term	−0.064	−0.157 *	0.445	0.546	−0.093	−0.089	−0.110	0.490	0.400	−0.075
	(0.045)	(0.083)	(0.404)	(0.846)	(0.078)	(0.056)	(0.103)	(0.456)	(0.974)	(0.096)
Wald chi^2	215.90	78.85	43.64	42.83	54.44	246.27	117.02	66.50	56.21	78.26
Observed value	126	126	126	126	126	126	126	126	126	126

Note: *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively. The numbers stated within parentheses are the t-statistics.

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