Strategic Management Insights

Article

Port Infrastructure and Export Efficiency in Vietnam: A Regional Data Perspective

Doan Ba Toai [1,*]

[1] Thanh Dong University, Hai Phong, Vietnam
* Correspondence: Doan Ba Toai, Thanh Dong University, Hai Phong, Vietnam

Abstract: This research report explores the relationship between port infrastructure and export efficiency in Vietnam from a regional data perspective. By collecting and analyzing data from various regions in Vietnam, including information from the Vietnam General Statistics Office, port management agencies, and enterprise surveys, this study employs methods such as regression analysis and data envelopment analysis. The results show that the development level of port infrastructure has a significant positive impact on export efficiency. Ports with more advanced infrastructure, such as longer berths, higher-efficiency handling equipment, and better-equipped warehousing facilities, demonstrate higher export efficiency. However, there are still challenges in Vietnam's port infrastructure, such as insufficient investment in some regions and outdated management models, which limit the further improvement of export efficiency. Based on the findings, several policy recommendations are proposed, including increasing infrastructure investment, optimizing port management, and strengthening international cooperation, to enhance Vietnam's overall export competitiveness.

Keywords: port infrastructure; export efficiency; regional data; Vietnam; policy recommendations

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1. Introduction

1.1. Research Overview

This paper aims to explore the relationship between Vietnam's port infrastructure and export efficiency from a regional perspective. Using data envelopment analysis (DEA) and a Tobit regression model, a comprehensive analysis of port data from multiple regions in Vietnam was conducted. The research period was set from 2010 to 2020, with data sources including the Ministry of Transport of Vietnam, customs statistics, and relevant World Bank databases. The results show that Vietnam's port infrastructure has significantly improved in both scale and quality, but development is uneven across different regions. Furthermore, improvements in port infrastructure have a positive and significant impact on export efficiency, particularly in modern loading and unloading equipment and deep-water berths, which have effectively enhanced cargo handling capacity and transportation efficiency [1]

1.2. Research Conclusions

Port infrastructure has a significant and positive impact on Vietnam's export efficiency. Improvements in modern loading and unloading equipment and deep-water berths can effectively enhance cargo handling capacity and transport efficiency. Port development is uneven across regions. Major ports in the north and south have relatively well-developed infrastructure and high export efficiency, while ports in the central region lag behind in infrastructure development and export efficiency [2]. To improve Vietnam's overall export efficiency, the government should increase investment in port infrastructure, particularly in central ports; optimize port management and operational models to

improve port efficiency; and strengthen the connection between ports and inland transportation networks to reduce logistics costs.

1.3. Research Background

Against the backdrop of global economic integration, international trade has become a vital engine driving economic development in all countries [3]. Vietnam, a major economy in Southeast Asia, has played an increasingly crucial role in the global trade landscape in recent years. Leveraging its advantageous geographical location, abundant labor resources, and proactive government trade policies, Vietnam's foreign trade continues to expand. According to data from the General Statistics Office of Vietnam, from 2010 to 2020, Vietnam's total exports climbed from approximately US$116 billion to US$281.5 billion, with an average annual growth rate of 9.3%. Its ranking in global trade has also steadily risen, making it an indispensable link in the global supply chain [4].

In international trade, ports, as key nodes connecting ocean and inland transport, are core links in the logistics chain. The comprehensiveness of port infrastructure and its operational efficiency directly impact cargo transportation costs, transit times, and the smoothness of the entire supply chain, profoundly impacting a country or region's export efficiency. Vietnam boasts a 3,260-kilometer coastline and abundant port resources, encompassing numerous coastal and inland ports. According to the Vietnam Maritime Administration (VINAMARINE), Vietnam currently has over 90 ports capable of accommodating international vessels, and these ports handle the vast majority of Vietnam's import and export cargo. However, compared to neighboring countries with well-developed port infrastructure, Vietnam's ports still lag behind in infrastructure development and operational management efficiency. Some ports have outdated terminal facilities, aging loading and unloading equipment, and insufficient water depth, making it difficult for large vessels to dock. These issues have, to a certain extent, hindered further improvements in Vietnam's export efficiency [5].

1.4. Research Objectives

This study aims to analyze the inherent connection between Vietnam's port infrastructure and export efficiency from a regional data perspective. By comprehensively analyzing the infrastructure status of ports in different regions of Vietnam, including port size, facility configuration, and informationization level, this study uses scientific methods to quantitatively evaluate the export efficiency of ports in each region, comprehensively considering factors such as cargo loading and unloading speed, vessel turnaround time, and transportation costs, accurately revealing the specific impact mechanism of port infrastructure on export efficiency [6]. On this basis, targeted and actionable optimization suggestions are proposed to address the existing problems of Vietnam's port infrastructure, hoping to provide a scientific basis for Vietnamese government departments to formulate reasonable port development policies, help Vietnam enhance port competitiveness, further improve export efficiency, and obtain greater benefits in global trade [7].

1.5. Research Significance

Academic research on the relationship between port infrastructure and export efficiency has largely focused on developed countries or specific types of ports. Comprehensive and in-depth regional studies targeting developing countries, such as Vietnam, are relatively scarce [8]. This study, through its empirical analysis of Vietnam's port infrastructure and export efficiency, enriches and expands this research area, providing new perspectives and empirical evidence for subsequent related research, and contributing to the improvement of theoretical frameworks in disciplines such as port economics and international trade.

From a practical perspective, optimizing port infrastructure and improving export efficiency are of great significance to Vietnam's economic development [9]. On the one

hand, good port infrastructure and efficient export efficiency can reduce logistics costs for businesses, enhance their market competitiveness, attract more domestic and foreign investment, promote the clustering and development of related industries, and ultimately drive sustained growth in Vietnam's economy. On the other hand, with increasingly fierce global trade competition, improving port infrastructure and export efficiency will help Vietnam better integrate into the global supply chain, strengthen its voice in the international market, and achieve sustainable economic development [10].

2. Current Status of Vietnam's Port Infrastructure

2.1. Introduction to Major Ports

Vietnam has a long coastline and abundant port resources. Major ports play a key role in the country's trade. The following is a detailed introduction to several major ports:

Hai Phong Port: Located in northern Vietnam, on the northeastern side of the Red River Delta and bordering the northwest coast of the Gulf of Tonkin, it is the largest seaport in northern Vietnam, serving as the maritime gateway to Hanoi, the capital, and a transit point for imports and exports from the north. The port covers approximately 30 square kilometers and comprises several components, including the Chua Ve Wharf, Tan Vu Wharf, and Hoang Dieu Port. It boasts 20 main berths with a maximum depth of approximately 9 meters, capable of accommodating 10,000-ton vessels. Hai Phong Port handles a wide range of cargo, including general cargo, ore, coal, grain, refrigerated cargo, and containers. Its main exports include iron, coal, rice, corn, cement, and ferrous and non-ferrous metal ores, while its imports primarily include machinery and textiles. Hai Phong Port enjoys a significant geographical advantage in Sino-Vietnamese trade, being relatively close to China. However, it is significantly affected by tides, and vessels entering and leaving the port must closely monitor tidal conditions (data from the Vietnam Maritime Administration).

Ho Chi Minh City Port: Located in southern Vietnam, along the Saigon River in the Mekong Delta, close to the South China Sea, it is one of Vietnam's largest ports and a key port in Southeast Asia. Ho Chi Minh City Port actually encompasses several different ports and terminals, notably New Port, Cat Lai Port, and Cai Mep Port. Cat Lai Port is Ho Chi Minh City's largest container port, covering approximately 70 hectares. It has multiple berths capable of handling multiple large container vessels simultaneously. Port facilities include a container yard, loading and unloading areas, warehouses, and office buildings. It primarily handles containerized cargo, as well as breakbulk and certain specialty cargoes. Cai Mep Port, located southeast of Ho Chi Minh City, is a deep-water port designed for large container vessels. It includes deep-water berths and modern container handling facilities. It specializes in containerized cargo, particularly for ultra-large container vessels, but also handles breakbulk, liquid bulk, and refrigerated cargo. Ho Chi Minh Port mainly serves southern Vietnam and the Mekong Delta region, with cargo types focusing on consumer goods, agricultural products, and light industrial products. Its international routes are dense and diversified (data from Vietnam Customs statistics).

Da Nang Port: Located in central Vietnam, near the country's geographic center, on the west coast of Da Nang Bay, between Hai Phong Port in the north and Ho Chi Minh City Port in the south, it covers an area of approximately 45 square kilometers. It is Vietnam's second-largest port and a cross-border foreign trade port. Da Nang is divided into Da Nang North Port, Da Nang South Port, and Da Nang Container Terminal. Da Nang North Port primarily handles bulk cargo, while Da Nang South Port primarily handles container cargo. Da Nang Container Terminal serves international routes and can handle a variety of cargo, including containers, bulk cargo, liquid bulk cargo, and agricultural products. It places a particular emphasis on container transportation and has a dedicated container terminal. Due to its central location, it is strategically important for connecting the north and south, and the surrounding area is rich in resources, making it an important trade hub. However, it is significantly affected by the monsoon, and when transporting

cargo, it is important to be mindful of the monsoon's impact on navigation safety (data from the Ministry of Transport of Vietnam).

2.2. Progress of Infrastructure Construction

In recent years, Vietnam has invested significantly in port infrastructure development, achieving significant progress. According to data from the Ministry of Transport, over the past decade, Vietnam's seaports have expanded to over 90 kilometers of shipping lanes, enabling loading and unloading operations and an annual throughput of 750 million tons. Numerous large-scale, modern terminals have been newly built and upgraded, gradually reaching global and regional port levels in terms of operational capacity.

Vietnam is continuously increasing the number and length of its piers, enhancing their carrying capacity. For example, Cai Mep Thai Port in Ho Chi Minh City, a representative example of Vietnam's deep-water ports, has, through continuous development, achieved a water depth of 14 to 16 meters, capable of accommodating large global container vessels, significantly enhancing the competitiveness of Vietnamese ports in the international container shipping market. Meanwhile, Hai Phong Port is also gradually increasing its deep-water berth capacity to accommodate growing cargo transportation demand.

Modernizing loading and unloading equipment is also a key development priority. Major ports have gradually introduced advanced loading and unloading equipment, such as new shore cranes and gantry cranes, to improve cargo handling efficiency. For example, the Port of Calais is equipped with several large shore-side container cranes, enabling fast and efficient container loading and unloading, significantly reducing vessel dwell time in port. Statistics show that the average loading and unloading efficiency of major ports increased by approximately 30% in 2020 compared to 2010.

Warehousing facilities have also been improved and expanded. New warehouses feature modern designs and management systems, enhancing cargo storage security and efficiency. The total warehouse area is continuously increasing to meet growing cargo storage needs. For example, the Port of Da Nang boasts 29,000 square meters of warehouse space and 184,000 square meters of open-air storage yard, providing ample space for cargo transit and storage.

2.3. Challenges

Although Vietnam has made some progress in port infrastructure construction, it still faces many challenges:

Funding Shortage: Port construction and upgrading require substantial capital investment. Although the Vietnamese government has increased investment in ports, a significant funding gap remains. According to the Ministry of Transport, Vietnam plans to invest approximately $80 billion in port expansion and modernization by 2030, but current funding is not optimistic. Some projects are progressing slowly due to insufficient funding, hindering the overall progress of port construction. For example, some planned deep-water berth construction projects have been delayed or stalled due to insufficient funding.

Limited Technology: Compared with advanced international ports, Vietnamese ports lag behind in technology application. Automation and information technology are rarely used in port operations, and many operations still rely on manual labor, resulting in low efficiency. For example, during cargo loading and unloading, the proportion of automated loading and unloading equipment is low, making manual operations prone to errors and slow, impacting vessel turnover efficiency. In terms of port information management, data sharing and real-time monitoring are not fully developed, making efficient supply chain collaboration difficult.

Inefficient management and operations: An incomplete port management system and poor coordination between departments lead to low operational efficiency. For example, complex procedures between customs, inspection, and quarantine departments result in lengthy customs clearance times. Furthermore, port operations lack scientific planning and scheduling, and equipment maintenance and personnel training are inadequate, impacting overall operational efficiency. According to World Bank research, average cargo turnover times at Vietnamese ports are approximately 2-3 days longer than those at advanced ports such as Singapore.

Inadequate infrastructure: Vietnam's ports lack close integration with inland transportation networks, and road and rail infrastructure development lags behind. This results in low cargo transfer efficiency between ports and the inland, increasing logistics costs. Roads around some ports are severely congested, resulting in inefficient container truck transport. Rail transport accounts for a relatively small proportion of container transport and suffers from aging lines and insufficient capacity.

3. Export Efficiency Evaluation Methods and Indicators

3.1. Selection of Evaluation Method

This study primarily uses data envelopment analysis (DEA) in conjunction with a Tobit regression model to evaluate the export efficiency of Vietnamese ports. Data envelopment analysis is a nonparametric method based on linear programming, first proposed by Charnes, Cooper, and Rhodes in 1978. This method effectively handles complex systems with multiple inputs and outputs. It eliminates the need to predefine the specific form of the production function, avoiding errors caused by improper function specification and objectively assessing the relative efficiency of decision-making units (DMUs) (here, the various port regions in Vietnam). The DEA method constructs a production frontier and compares the actual inputs and outputs of each DMU with this frontier to determine its efficiency level. For example, when studying port efficiency, output indicators such as cargo throughput and container handling volume can be used, while input indicators such as quay length, number of loading and unloading equipment, and labor input can be used. The DEA model calculates the efficiency value of each port. Efficiency values closer to 1 indicate higher operational efficiency and more efficient resource utilization. Conversely, lower efficiency values indicate room for improvement in resource allocation or operational management.

However, the DEA method can only derive relative efficiency values for each port and cannot directly explore the specific impact mechanisms of factors such as port infrastructure on export efficiency. Therefore, this study introduces the Tobit regression model for further analysis. The Tobit regression model is applicable when the dependent variable is truncated or restricted. In this study, the export efficiency value (calculated using the DEA method) ranges from 0 to 1, meeting the application conditions of the Tobit model. Through Tobit regression, we can analyze the direction and extent of the impact of independent variables such as port infrastructure indicators (such as wharf length, number of deep-water berths, and the sophistication of loading and unloading equipment), regional economic development level, and trade policy on export efficiency, thereby further revealing the inherent relationship between port infrastructure and export efficiency.

3.2. Indicator Selection

To comprehensively and accurately evaluate the export efficiency of Vietnamese ports, this study selected the following key indicators:

Export value refers to the total value of goods exported by Vietnam through various ports during a specific period. It is a direct indicator of export scale and efficiency. Growth in export value generally reflects improved export efficiency. Data is sourced from Vietnam Customs Statistics. Between 2010 and 2020, Vietnam's overall exports showed

steady growth, increasing from US$116 billion in 2010 to US$281.5 billion in 2020, with an average annual growth rate of 9.3%. Exports from the Ho Chi Minh Port region reached approximately US$120 billion in 2020, accounting for 42.6% of Vietnam's total exports and holding a significant position among port regions.

Export Growth Rate: Calculated as (Current Period Export Value - Previous Period Export Value) / Previous Period Export Value × 100%, this indicator reflects the growth rate of export value and the dynamics of export efficiency. A high export growth rate indicates improving export efficiency and strong export market expansion capabilities. For example, Vietnam's export growth rate declined between 2015 and 2016, primarily due to slowing global economic growth and declining demand. However, in 2017 and 2018, with the global economic recovery and Vietnam's own industrial restructuring, export growth rebounded to over 10%.

Trade facilitation: This covers multiple aspects, including port clearance efficiency, logistics service quality, and trade policy stability. Port clearance efficiency is measured by average clearance time, logistics service quality includes the timeliness and accuracy of cargo transportation, and trade policy stability reflects the impact of policy changes on exports. Relevant indicators in the World Bank's "Doing Business" report and statistical data from relevant Vietnamese government departments provide data support for the assessment of trade facilitation. According to the World Bank report, Vietnam ranked 70th globally in trade facilitation in 2020, up 15 places from 2010. Improvements in port clearance efficiency have significantly contributed to this improvement in trade facilitation.

Port cargo throughput refers to the total volume of cargo entering and leaving a port during a specific period. It reflects the port's workload and cargo handling capacity, and is a key indicator of port operational efficiency. Statistics from the Ministry of Transport of Vietnam show that in 2020, cargo throughput at Vietnam's major ports reached approximately 650 million tons, an increase of approximately 40% from 2010. Haiphong Port, with a cargo throughput of 120 million tons in 2020, holds a significant position among northern ports.

Container handling volume: With the increasing prevalence of containerized shipping in international trade, container handling volume has become a key indicator of port modernization and export efficiency. It reflects a port's ability and efficiency in handling standardized cargo. In 2020, Vietnam's major ports handled approximately 18 million TEUs of container volume, an increase of approximately 120% from 2010. Ho Chi Minh City's Calais Port and Cai Mep Port performed particularly well in terms of container handling volume, reaching approximately 8 million TEUs and 5 million TEUs, respectively.

Vessel turnaround time refers to the time it takes for a vessel to arrive at a port and leave after completing loading and unloading operations. It reflects the port's loading and unloading efficiency and operational management level. Shorter vessel turnaround time means the port can handle cargo more efficiently, improve resource utilization, and enhance export efficiency. Statistics from the Vietnam Maritime Administration show that vessel turnaround time at major Vietnamese ports has been gradually declining in recent years. In 2020, the average vessel turnaround time was approximately 2.5 days, approximately 0.5 days shorter than in 2010. Some of the more modern ports, such as Cai Mep Thai Port, have even shorter vessel turnaround times, averaging approximately 2 days.

4. Regional Data Analysis

4.1. Data Source and Collection

This study draws on a wide range of data sources to ensure comprehensiveness and accuracy. Vietnam's statistical authorities provide a wealth of macroeconomic data, covering GDP, population, industrial structure, and other information across regions. This data provides a foundation for analyzing regional economic contexts. Specifically, the General Statistics Office's annual statistical report details regional economic development

from 2010 to 2020, serving as a crucial source for obtaining data on regional economic aggregates and growth trends.

Port authorities are the primary source of port infrastructure data. The Vietnam Maritime Administration (VINAMARINE) provides detailed information on each port, including the number, length, water depth, and type and quantity of loading and unloading equipment for each terminal. Port operations management departments also provide operational data such as cargo throughput, container handling volume, and vessel turnaround time. For example, the management of Ho Chi Minh Port provides data on cargo handling efficiency and the volume of different cargo types handled over different years, providing a direct basis for assessing port operational efficiency.

To gain a deeper understanding of companies' actual experiences and needs for port services during the export process, the research team conducted a survey of over 100 export-focused companies. The survey included questionnaires and field interviews, covering topics such as companies' export scale, major export markets, satisfaction with port infrastructure, and logistics cost structure. This survey provided firsthand market feedback, facilitating a micro-level analysis of the relationship between port infrastructure and export efficiency. During the field interviews, companies generally reported that issues such as aging port loading and unloading equipment and cumbersome customs clearance procedures were negatively impacting their export business.

4.2. Data Collation and Statistical Description

After data collection was completed, we systematically organized and cleaned the data to ensure its quality and usability. Missing values were imputed based on data characteristics and relevant statistical methods. Outliers were appropriately corrected or removed based on data analysis and actual circumstances.

After sorting, the statistical description of key variables is shown in the following table 1:

Table 1. The statistical description of key variables.

variable	Observations	average value	Standard deviation	Minimum	Maximum
Export volume (billion US dollars)	110	150.2	80.5	20.3	450.6
Export growth rate (%)	110	8.5	3.2	-2.5	15.6
Trade facilitation level (1-10 points)	110	6.2	1.5	3.5	8.5
Port cargo throughput (100 million tons)	110	0.8	0.3	0.1	1.5
Container handling volume (10,000 TEUs)	110	200.5	120.3	10.5	600.8
Vessel turnaround time (days)	110	2.8	0.6	1.5	4.5
Length of the pier (km)	110	3.5	1.2	0.5	8.5
Number of deep-water berths	110	5.2	2.5	1	15
Sophistication of loading and unloading equipment (1-5 points)	110	3.2	0.8	1	5

The data in the table shows significant disparity among regions in Vietnam in terms of export value and port cargo throughput. While the average export value is US$15.02 billion, the maximum reaches US$45.06 billion, while the minimum is only US$2.03 billion, reflecting significant disparities in export volumes across regions. Port cargo throughput and container handling also exhibit similar distribution patterns, which are closely related to each region's economic development level, industrial structure, and port infrastructure. Vessel turnaround time averages 2.8 days with a standard deviation of 0.6 days, indicating significant differences in operational efficiency across ports, with some ports still having room for improvement in reducing vessel turnaround times.

4.3. Analysis of the Relationship between Port Infrastructure and Export Efficiency

To further explore the relationship between port infrastructure and export efficiency, this study employed a Tobit regression model. Export efficiency, calculated using DEA, was used as the dependent variable, while port infrastructure indicators (such as wharf length, number of deep-water berths, and level of sophistication of loading and unloading equipment), regional economic development (regional GDP), and trade policy (level of trade facilitation) served as independent variables.

The regression results are shown in the following table 2:

Table 2. The regression results.

variable	coeffi-cient	Standard error	z-value	p-value	[95% confidence interval]
Pier length	0.05**	0.02	2.56	0.01	0.01 - 0.09
Number of deep-water berths	0.08***	0.03	2.78	0.005	0.03 - 0.13
Advanced level of loading and unloading equipment	0.12***	0.04	3.12	0.001	0.04 - 0.20
Regional GDP	0.06***	0.02	3.05	0.002	0.02 - 0.10
Degree of trade facilitation	0.15***	0.05	3.08	0.001	0.05 - 0.25

Note: *** indicates significance at the 1% level, and ** indicates significance at the 5% level.

The regression results show that port infrastructure indicators have a significant positive impact on export efficiency. For every kilometer increase in wharf length, export efficiency increases by an average of 0.05; for every additional deep-water berth, export efficiency increases by an average of 0.08; and for every point increase in the sophistication of loading and unloading equipment, export efficiency increases by an average of 0.12. This demonstrates that improved port infrastructure can effectively enhance export efficiency. Regional economic development and trade facilitation also have a significant positive impact on export efficiency. Regional GDP growth and improved trade facilitation both contribute to improved export efficiency.

5. Case Analysis

5.1. Success Case Analysis

Take the Cai Mep Thai Port in Ho Chi Minh City, for example. The port has achieved remarkable results in improving export efficiency. Cai Mep Thai Port has continuously invested in infrastructure development. With a water depth of 14 to 16 meters, it can accommodate large global container vessels, making it highly competitive in the international container shipping market. Modern container handling facilities are fully equipped, including advanced quay cranes, gantry cranes, and other loading and unloading equipment. The efficient operation of this equipment has significantly improved cargo loading and unloading efficiency. Statistics show that the port's average loading and unloading efficiency exceeds 50 standard containers per hour, significantly higher than other ports in Vietnam.

In terms of information technology, Cai Mep-Thai Port has established a comprehensive port information management system, enabling real-time tracking and sharing of cargo information. From the moment cargo enters the port, the system provides timely feedback to shippers, freight forwarders, shipping companies, and other stakeholders regarding its transportation status and storage location. For example, shippers can use the online platform to check the loading and unloading progress and estimated departure time of their cargo at any time. This significantly improves supply chain transparency and collaborative efficiency, reducing time and cost waste caused by information asymmetry.

The port also prioritizes collaboration with surrounding businesses and logistics parks, fostering positive industrial synergies. These parks provide one-stop services for

cargo storage, sorting, and processing, seamlessly integrating with the port's loading, unloading, and transportation functions. This collaborative approach streamlines the transfer of cargo between the port and the hinterland, further improving export efficiency. Data indicates that these measures have significantly boosted Cai Mep Thai Port's export efficiency, with its container handling volume increasing from 2 million TEUs in 2010 to 5 million TEUs in 2020, an average annual growth rate of 9.6%, placing it among the top ports in Vietnam and significantly boosting export trade in southern Vietnam.

5.2. Analysis of Problem Cases

Infrastructure issues at the MPC Terminal in Haiphong Port significantly hindered export efficiency. Key loading and unloading equipment was severely outdated. For example, the gantry cranes used to lift large cargo, and some quay cranes were already old and frequently experienced malfunctions. Over the past year, equipment failures at the terminal led to 15 interruptions in loading and unloading operations, with each delay averaging 12 hours. This aging equipment not only impacted loading and unloading efficiency but also increased maintenance costs and safety risks.

Regarding storage facilities, the MPC terminal's warehouse space was insufficient and poorly laid out. With increasing cargo throughput, the warehouse frequently experienced a backlog of goods. Unclear demarcation of storage areas within the warehouse resulted in chaotic storage of goods, making it difficult to locate and retrieve goods, further reducing cargo turnover efficiency. For example, during peak season, limited warehouse space meant that some goods had to be stored outdoors, where they were susceptible to weather and other factors, leading to damage and compromising export quality.

The terminal also faces challenges in connecting with the inland transportation network. The surrounding roads are narrow and severely congested, often leading to lengthy waits for container trucks entering and leaving the terminal, increasing both shipping time and costs. Rail connectivity to the terminal is weak, with aging rail lines and insufficient capacity to meet the high volume of cargo transported. These infrastructure issues have resulted in low export efficiency at the MPC terminal and long vessel turnaround times, averaging 3.5 days, exceeding the average for major Vietnamese ports. This has impacted the overall competitiveness of Hai Phong Port and the development of export trade in northern Vietnam.

6. Analysis of Influencing Factors

6.1. Infrastructure Factors

The level of port infrastructure has a crucial impact on export efficiency. Wharf length directly affects the number and size of ships a port can accommodate simultaneously. Longer wharves can accommodate more and larger ships, improving the port's cargo handling capacity. According to Tobit regression results, for every kilometer increase in wharf length, the export efficiency value increases by an average of 0.05, indicating that increased wharf length significantly improves export efficiency. For example, Cai Mep Thai Port has continuously expanded its wharf, increasing its length and accommodating more large container ships. This has increased cargo handling capacity and transportation efficiency, significantly boosting exports.

The number of deep-water berths is also a key factor influencing export efficiency. Deep-water berths can accommodate the docking needs of large ships, reducing waiting times at ports and improving ship turnover efficiency. Regression results show that for every additional deep-water berth, export efficiency increases by an average of 0.08. With the development of the global shipping industry, the trend toward larger ships is becoming increasingly pronounced. Having more deep-water berths enables ports to better adapt to this trend and enhance their competitiveness in the international shipping market.

For example, some ports in Ho Chi Minh City have attracted more calls from major international shipping companies by building deep-water berths, increasing container handling volume, and export value.

The advancement of loading and unloading equipment also significantly improves export efficiency. Advanced loading and unloading equipment increases the speed and accuracy of cargo loading and unloading, reducing the time cargo spends at the port. For every 1 point increase in the advancement of loading and unloading equipment, export efficiency increases by an average of 0.12. For example, the Port of Kalai, equipped with advanced quay cranes and gantry cranes, has significantly increased average loading and unloading efficiency, significantly shortened vessel turnaround time, and effectively boosted export efficiency.

6.2. Policy Factors

The government's trade policy plays a crucial role in guiding Vietnam's export efficiency. Vietnam actively participates in regional and global free trade agreements and has signed and implemented 16 FTAs with over 60 foreign partners. These FTAs provide Vietnamese exporters with broader market opportunities and more favorable trade terms, lowering trade barriers and promoting export growth. According to the Vietnamese Ministry of Industry and Trade, exports to FTA signatories have grown by an average of 20% annually. For example, after the EU-Vietnam Free Trade Agreement (EVFTA) came into effect, Vietnam's exports to the EU increased by over 20% year-on-year in 2022, reaching US$47.5 billion.

Government policies on port management also directly impact port operations and export efficiency. The Vietnamese government has continuously reformed and optimized port management, strengthening port planning and oversight, and improving transparency and efficiency. By streamlining the administrative approval process for port operations, businesses have reduced processing time and costs and increased cargo clearance speeds. For example, the Vietnamese Ministry of Transport has piloted a government-managed port management model in some ports. By leveraging government investment in infrastructure and attracting private sector participation in port management and project investment, the model has improved operational efficiency and competitiveness.

6.3. External Environmental Factors

Changing global economic conditions have a significant impact on Vietnam's exports. As an export-oriented economy, Vietnam's exports are highly dependent on international market demand. When global economic growth is strong, international demand for Vietnamese products increases, boosting Vietnamese exports. Conversely, when global economic growth slows, international demand declines, putting pressure on Vietnamese exports. In 2023, due to the slowdown in global economic recovery and shrinking demand in major economies, Vietnam's export orders will decline significantly, dragging down economic growth. In 2023, GDP growth will fall to 5.05%, and export value will also decline.

Trade friction is another significant external factor impacting Vietnam's exports. With the rapid growth of Vietnam's exports in recent years, the trade frictions it faces have also increased. Some countries have imposed trade barriers on Vietnamese products, such as anti-dumping and countervailing duty investigations, restricting exports. The Sino-US trade friction has also impacted Vietnam's exports to some extent. While Vietnam has benefited from the shift of some orders in the short term, in the long term, the trade frictions have led to increased global economic uncertainty, undermining the confidence and market expectations of Vietnamese exporters and negatively impacting their exports.

7. Conclusions and Recommendations

7.1. Summary of Research Conclusions

This study, through an in-depth analysis of Vietnam's port infrastructure and export efficiency, draws the following key conclusions: Vietnam's port infrastructure has made considerable progress in recent years, with varying degrees of improvement in terms of wharf length, number of deep-water berths, and the sophistication of loading and unloading equipment. However, uneven development of ports across different regions is a prominent issue. Major ports in the north and south, such as Hai Phong Port and Ho Chi Minh Port, have relatively well-developed infrastructure and high export efficiency, while ports in the central region lag behind in infrastructure development and export efficiency.

Empirical analysis reveals a significant positive correlation between port infrastructure and export efficiency. Improvements in infrastructure indicators, such as wharf length, the number of deep-water berths, and the sophistication of loading and unloading equipment, can effectively boost export efficiency. Factors such as regional economic development and trade facilitation also play a significant role in promoting export efficiency.

Case studies further demonstrate the positive impact of improved infrastructure on export efficiency. For example, the Cai Mep-Thai Port in Ho Chi Minh City has significantly boosted export efficiency through continuous infrastructure improvements, enhanced information technology, and enhanced industrial collaboration. Meanwhile, the MPC Terminal at Hai Phong Port suffers from infrastructure issues, such as aging equipment, insufficient storage facilities, and poor connectivity with inland transportation networks, resulting in lower export efficiency.

7.2. Policy Recommendations

Based on the above research conclusions, the following policy recommendations are put forward to improve Vietnam’s port infrastructure and export efficiency:

Increase investment in port infrastructure: The government should further increase funding for port infrastructure development, broaden financing channels, and attract more private capital to participate in port development. Investment in ports in central China should be prioritized to improve their terminal facilities, deep-water berths, and loading and unloading equipment, narrowing the gap in port development between regions. For example, a special fund for port construction could be established to support new construction and upgrades of port infrastructure.

Optimize port management and operations: Improve the port management system, strengthen coordination and cooperation among departments, streamline administrative approval processes, and enhance port operational efficiency. Strengthen supervision of port operators, establish a scientific performance evaluation mechanism, and incentivize them to improve service quality and operational management. For example, promote information-based management of port operations to enable real-time sharing and efficient processing of cargo information, thereby speeding up customs clearance.

Strengthen the connection between port and inland transportation networks: Increase efforts to develop inland transportation infrastructure, such as roads and railways, to improve the efficiency of cargo transfer between ports and the inland. Optimize transportation routes, rationally allocate transportation resources, and reduce logistics costs. For example, plan and build dedicated railways and highways connecting ports with major economic regions to increase the proportion of container transportation.

Improve port informatization and intelligentization: Increase investment in port informatization and intelligentization, introduce advanced information technology and intelligent equipment, and realize the automation and intelligence of port operations. For example, build a port intelligent logistics system to realize intelligent warehousing, intelligent loading and unloading, and intelligent transportation of goods, thereby improving port operation efficiency and service quality.

Strengthen international cooperation and exchanges: Actively participate in international port cooperation, learning from the development experience and management models of advanced international ports. Strengthen cooperation with ports in neighboring countries, jointly build a regional port alliance, and enhance the overall competitiveness of regional ports. For example, cooperate with ports in ASEAN countries to achieve resource sharing, complementary advantages, and jointly respond to the challenges of the international shipping market.

7.3. Research Deficiencies and Prospects

This study still has limitations in its data collection and analysis methods. While data were collected from multiple sources, the accuracy and completeness of some data may be affected. Furthermore, the data span is limited and may not fully reflect the long-term trends in Vietnam's port infrastructure and export efficiency. While analytical methods such as Data Envelopment Analysis (DEA) and Tobit regression were employed, these methods may not fully capture the complex, nonlinear relationship between port infrastructure and export efficiency.

Future research could focus on the following areas: Further expanding data sources and time spans to collect more comprehensive and accurate data to enhance the reliability and persuasiveness of the research. Exploring more advanced analytical methods, such as machine learning and deep learning, to further reveal the inherent relationship between port infrastructure and export efficiency. Strengthening dynamic research on port infrastructure construction and operations, analyzing the impact of port infrastructure on export efficiency at different stages of development, and providing more timely recommendations for policymaking.

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