

Research on the Development and Policies of the Port of Singapore Harbor

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Abstract: The Port of Singapore has long been renowned for its outstanding development and effective policies. This paper delves into a comprehensive study of the key characteristics, infrastructure development, and critical policies formulated by the government for the Port of Singapore. Through both quantitative and qualitative analyses of port development, it reveals the factors contributing to its success as well as the challenges it faces. The paper explores innovative initiatives taken by the Singaporean government in port management, including trade facilitation, digital technology applications, and sustainable development. Emphasizing flexibility in response to changes in the global trade environment highlights the Port of Singapore's ability to maintain competitiveness. Finally, the paper puts forth recommendations to further enhance the competitiveness of the Port of Singapore and foster its position in the global supply chain. This study contributes to a deeper understanding of the success of the Singaporean port model, providing valuable insights for the sustainable development of other ports.

Keywords: Port Automation, Free Trade Policies, Port Operational Efficiency, and Smart Port Construction

1. Introduction

The Port of Singapore (SGSIN), as the world's second-busiest port, serves as the operational hub for PSA International Pte Ltd. Originating from the 13th century as an international trade port, it has evolved into one of the most crucial transshipment hubs globally. Its strategic geographical location positions it as a key node for maritime transportation between the Pacific and Indian Oceans, also serving as the focal point for Singapore's political, economic, cultural, and transportation activities. This paper will delve into the characteristics, operational management, and significance to global trade of the Port of Singapore. Comparative analyses with ports such as Shanghai and Hong Kong will be conducted to unveil its unique position in the international shipping system and its profound impact on the global economy.

2. The Main Characteristics of the Port of Singapore

2.1. Industrial Structure

SGSIN, situated in Singapore, lies to the southeast of the Malacca Strait and to the north of the Singapore Strait, serving as a crucial international maritime hub between the Pacific and Indian Oceans. As one of the world's busiest ports, second only to Shanghai Port, it holds a strategic position in the maritime transportation choke point between the Pacific and Indian Oceans. Originating as an international trade port in the 13th century, it has evolved into a globally recognized transshipment hub. The Port of Singapore also serves as the central hub for the country's political, economic, cultural, and transportation activities.

Presently, SGSIN is one of the largest transshipment hubs in the Asia-Pacific region and ranks among the busiest container ports globally, with a ship entering or leaving approximately every 12 minutes, earning its reputation as the "world's most efficient port." The main industries include electronics, refining, and shipbuilding as the three pillars. The port's high-tech sector has rapidly developed, making Singapore a major producer of computer chips and integrated circuits globally. Singapore is a leading fuel supply port globally and ranks as the third-largest petroleum refining center worldwide. In addition to the three main pillars, the industrial landscape includes developments in textiles, food, transportation equipment, and construction. Singapore serves as a central hub for aviation in Europe, Asia, and the Pacific regions, with tourism being a significant source of foreign exchange.

SGSIN is operated by PSA, the world's second-largest port operating management company. Its predecessor, The Port of Singapore Authority, was established on April 1, 1964, and was responsible for coordinating and managing all operations of the Port of Singapore. On August 25, 1997, the Parliament restructured the Port of Singapore Authority, forming PSA Corporation Ltd., which commenced operations on September 1 of the same year. In December 2003, PSA International Pte Ltd was established and positioned as a "global port operating company." By 2023, Singapore's global trade network covers over 600 ports in more than 120 countries. The industrial structure of the Port of Singapore primarily encompasses shipping, logistics, and related services. [1]As one of the world's busiest ports, it plays a pivotal role in goods transshipment and trade. The shipping industry is core, covering container, tanker, and bulk carrier transport. Logistics includes warehousing, freight, and distribution services. Furthermore, Singapore provides a range of maritime services, such as shipping agency, ship maintenance, and insurance, forming a comprehensive port industry ecosystem [2].

2.2. Port Operation Mode

The operational model of the Port of Singapore is highly modernized and efficient. Renowned for its highly automated container handling, the port utilizes advanced loading and unloading equipment along with intelligent technology to expedite cargo transfer, accommodating large volumes efficiently. Close collaboration with logistics companies has enabled the port to achieve a high level of integration in logistics. This encompasses the storage, transportation, and distribution of goods, ensuring the efficient circulation of cargo. The Port of Singapore employs advanced digital technologies such as the Internet of Things (IoT), big data analysis ability, and artificial intelligence to enhance operational efficiency, monitor cargo flow, and conduct predictive maintenance. A multi-modal transportation network, incorporating road, sea, and air routes, facilitates broader connectivity for cargo transportation. This contributes to strengthening Singapore's position as an international trade hub.

The Port of Singapore places emphasis on environmental sustainability and safety. The introduction of green technologies, such as electric vehicles and clean energy, is coupled with the

implementation of high-standard safety measures, ensuring the sustainability and safety of port operations. Overall, the Port of Singapore has established an advanced, efficient, safe, and sustainable operational model through high levels of automation, digitization, and logistics integration, laying a solid foundation for its competitiveness in international trade.

3. Comparative Study

3.1. Comparison with Shanghai Port

Table 1: Comparison of basic conditions of Singapore Port and Shanghai Port

	Port of Singapore	Port of Shanghai
Container berth (one)	57	49
Quay length (meter)	17,350	91,600
Area (hectare)	700	3,620
Dock crane (one)	212	578
Design production capacity (TEU)	40,000,000	49,000,000
Industrial structure	Container, admiralty fuel, ship repair	Container, bulk and general cargo, fluid cargo
Storage space (million square meter)	349.6	758

In terms of industrial structure, Shanghai Port boasts a diversified portfolio including container, bulk, liquid, and general cargo. Among these, container transportation takes the lead, with Shanghai ranking first globally in container throughput. It possesses robust integrated transportation capabilities, emphasizing not only containerized cargo but also bulk cargo transportation such as liquid chemicals and steel. In terms of port operation and management, Shanghai Port employs modern handling equipment and technologies, boasting significant container handling capacity. It emphasizes highly integrated transportation networks, emphasizes multi-modal transport, and connects land, sea, and air routes. Shanghai Port also emphasizes safety management, implementing high standards for equipment and operations safety, and prioritizes environmental protection and sustainability.[3]

Overall, Singapore Port focuses on high-value-added services and diversified maritime services, featuring highly automated container handling systems. On the other hand, Shanghai Port, with its vast scale and dominance in container transportation, emphasizes multi-modal transport and global transportation networks. Both reflect common trends in modern ports regarding technological applications, logistics integration, safety management, and environmental sustainability. However, they differ in terms of industrial structure and characteristics.

3.2. Comparison with Hong Kong Port

Comparing with Hong Kong port, Singapore port shares certain similarities in terms of industrial structure. Container transportation serves as the dominant sector in both, encompassing bulk and liquid cargo. Hong Kong boasts robust logistics and warehousing services, serving as a key Asian trade hub, ensuring efficient distribution of goods. It has developed financial and trade services, with the port being an integral part of Hong Kong's comprehensive service offerings. In terms of operational management, both ports rely on modern technology and equipment to enhance cargo throughput efficiency. They emphasize efficient logistics operations, providing crucial transshipment

services for global supply chains. Hong Kong port adheres to stringent safety standards and maintains a strong environmental consciousness, prioritizing social responsibility.

4. Singapore's Port Policy and Regulations

4.1. Free Trade Policy

Singapore's port policies are closely intertwined with its national strategy, particularly within the framework of its free trade policy. The emphasis on free trade is a pivotal component of Singapore's economic success and serves as a cornerstone of its national strategy. By fostering open markets, reducing tariffs, and promoting international trade, Singapore's free trade policy creates a conducive environment for port development. This approach attracts significant foreign investment and businesses to Singapore, driving the growth and expansion of its ports, thereby enhancing their competitiveness and international standing. At the national strategic level, Singapore actively participates in the formulation of free trade agreements, signing bilateral and multilateral agreements to provide its domestic businesses with broader market access and bolster their positions in international trade. Moreover, strategic investments in infrastructure such as ports, airports, and communication networks aim to improve the efficiency of goods and information flow. These investments not only enhance the competitiveness of Singapore's ports but also boost the efficiency of the entire supply chain, positioning Singapore as a crucial regional and global trade hub.[4]

4.2. Singapore's Customs Act

Under the taxation regulations outlined in Singapore's Customs Act, imported goods are categorized into dutiable and non-dutiable items based on whether they are subject to taxation. Dutiable goods include five major categories: petroleum, alcoholic beverages, tobacco products, motor vehicles, motorcycles with engines, and bicycles. All other goods are considered non-dutiable. Non-dutiable goods imported into Singapore are exempt from customs duties and domestic excise taxes, with only a 7% Goods and Services Tax (GST) applied. However, according to the Singaporean government's plan, at some point between 2021 and 2025, the GST rate is set to increase from 7% to 9%.

Singapore operates under a territorial tax system, employing a uniform tax regime nationwide. Any company or individual earning income in Singapore is required to pay taxes there, regardless of whether they are domestic or foreign entities. The Singaporean government incentivizes investment, exports, job creation, research and development, and the production of high-tech products by offering tax exemptions or financial support to multinational corporations, regional headquarters, technology research institutions, international shipping and freight companies, export-oriented enterprises, and businesses in specialized industries and services (such as high-tech and high-value-added enterprises) that constitute important elements of the knowledge economy. Singapore extends national treatment to foreign investments, ensuring that foreign-owned enterprises receive the same tax incentives and exemptions as domestic ones.

4.3. Green Port Regulation

In response to global concerns about sustainability, Singapore is also advancing environmental initiatives in port management. Measures are being taken to reduce carbon footprints, enhance energy efficiency, and promote the application of green technologies in port operations. Singapore has implemented a series of environmental regulations covering various aspects of port activities. These regulations include provisions on waste management, emission control, and resource management to ensure that port operations comply with environmental standards. Port authorities encourage the adoption of green technologies and innovations to reduce carbon emissions, improve energy

efficiency, and mitigate environmental impacts. This may involve the use of eco-friendly equipment, smart logistics systems, and clean energy sources. Additionally, ports have set carbon neutrality targets to reduce overall carbon footprints. This may include adopting renewable energy, promoting the use of electric vehicles, and implementing energy efficiency improvements. Port authorities take preventive measures, including monitoring and managing pollutant emissions, to maintain the ecological balance of surrounding waters and protect the marine environment.[5]

Singapore is the world's largest fuel center, selling a total of 47.9 million tons of fuel in 2023 (including liquefied natural gas and biofuels). In addition, the supply of alternative fuels in Singapore (including methanol, ammonia, hydrogen, and biofuels) is continuously increasing. Currently, sales of alternative fuels in Singapore (including about 140,000 tons of biofuel blends) have surpassed the sales of liquefied natural gas fuel (16,000 tons). Singapore is vigorously promoting decentralization in the shipping industry, aiming to achieve zero emissions by 2050. To achieve this goal, the Maritime and Port Authority of Singapore plans that starting from 2030, all new domestic harbor vessels operating in port waters must use zero-emission fuels, such as full electrification, B100 biofuels, or hydrogen fuels. To ensure a smooth transition, the Maritime and Port Authority has developed the world's first interim national standard for marine biofuels, specifying the blending standards of B50 biofuels, and will gradually improve the standards for B100 biofuels by 2025.

Singapore's ports are committed to reducing the carbon footprint of ports and ships by introducing green energy sources such as natural gas and electric ships to replace traditional fuels. This measure helps reduce air pollution and greenhouse gas emissions. Efforts to construct green infrastructure at ports include eco-friendly docks, wastewater treatment facilities, and waste treatment centers. The construction of these facilities helps minimize negative impacts on the surrounding environment. Singapore's ports adopt strict pollution monitoring and control measures, monitoring ship emissions, wastewater discharges, and taking corresponding measures to protect marine ecosystems. Ports implement comprehensive waste management plans, including waste sorting, recycling, and treatment. This helps minimize the impact of waste on the marine environment while promoting sustainable resource utilization.

Singapore's ports have established a greenhouse gas reporting system, publicly releasing carbon emissions data for ships and ports. In addition, setting emission reduction targets strives to reduce overall carbon footprints, promoting the sustainable development of ports and the shipping industry. Ports actively promote green technological innovations, including ship electrification and intelligent ship management systems. This helps improve the efficiency of the entire shipping industry while reducing environmental impacts. Ports collaborate with international organizations, adhering to international green standards and guidelines to ensure that local ports align with international environmental standards. This helps enhance the reputation of ports in the global green shipping arena. The introduction of a green ship certification system and incentive mechanisms encourages ships to adopt more environmentally friendly technologies and practices. This incentive mechanism helps accelerate the green transformation of the maritime industry. Overall, Singapore's green environmental regulations in the port and maritime industry take proactive measures in various aspects, including technological upgrades, infrastructure construction, waste management, and carbon emission control, making important contributions to the sustainable development of ports and the maritime industry.

5. Singapore Port's Future Outlook

5.1. Challenges and Threats

Singapore faces a series of challenges and issues in terms of port scale. Firstly, geographical limitations result in limited port capacity. Despite continuous expansion efforts through engineering

technologies, Singapore is still constrained by space limitations. This may lead to congestion of goods and vessels, impacting port efficiency. Secondly, global trade fluctuations pose uncertainties for Singapore's port. Economic instability and trade disputes may cause fluctuations in cargo volumes, affecting port operations. Additionally, adjustments in global supply chains may also affect Singapore's port, requiring flexible responses to market changes [6].

Table 2: Details of Singapore’s maritime performance 2013-2023
 Source: MPA

Year	Container throughput (Ten thousand TEU)	Cargo handling capacity (Ten thousand tons)	Fuel sales (Ten thousand tons)	Registered tonnage of ship (Million GT)
2023	3901	59170	5182	99.6
2022	3730	57770	4790	95.6
2021	3760	59960	5000	92.3
2020	3690	59070	4980	95.0
2019	3730	62650	4750	97.3
2018	3660	63010	4980	90.9
2017	3370	62770	5060	88.8
2016	3090	59330	4860	88.0
2015	3090	57580	4520	86.3
2014	3390	58130	4240	82.2
2013	3260	56090	4270	73.6

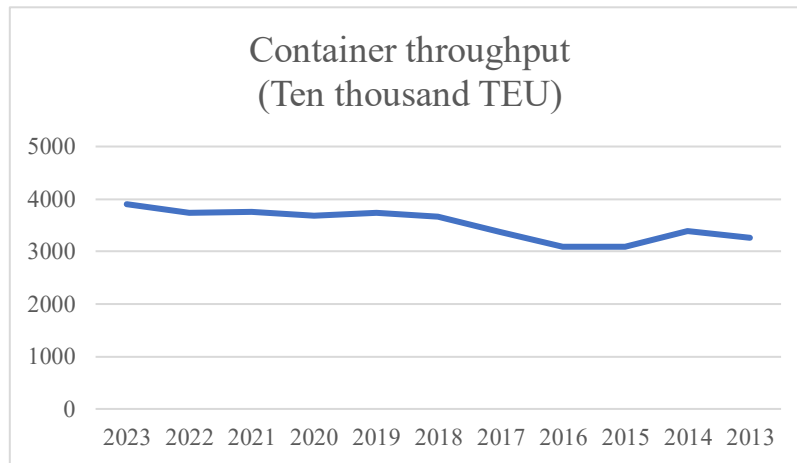


Figure 1: Container throughput of Singapore Port 2013-2023

Environmental sustainability is a significant consideration. Port operations have certain environmental impacts, including air and water pollution. As global attention on climate change and environmental protection increases, Singapore's port needs to take measures to reduce its environmental footprint, aligning with international standards and sustainability requirements. Lastly, the introduction of technological upgrades and automation is also a challenge. New technologies may require significant investment and training to ensure that ports remain competitive. Addressing these challenges requires comprehensive considerations, involving government policies, investment decisions, and coordinated efforts in port management.

Port operations in Singapore face challenges related to limited geographical space, leading to constraints on capacity and potential congestion, despite ongoing investments in expansion and

modernization. Bottlenecks in operations, including cargo handling and vessel movements, may impact service quality, causing delays and disruptions in the supply chain. Upgrading information technology and automation levels is crucial for enhancing operational efficiency, but inadequate integration of modern technologies could lead to coordination issues and inefficiencies. Moreover, ensuring sustainability and environmental friendliness in port services poses additional challenges that require proactive measures. Overall, addressing these challenges is essential for maintaining high operational efficiency and service quality in Singapore's ports.

5.2. Strengths and Opportunities

The development of smart ports and smart waterways involves upgrading specialized terminal production management systems for containers, petroleum, bulk grain, general cargo, minerals, and automotive goods, while promoting the integration of terminal operations. This includes the construction of a demonstration area for autonomous driving in ports, facilitated by the implementation of intelligent vehicle-road coordination systems, unmanned container truck control systems, and intelligent yard lane control systems, to scale up the application of autonomous container trucks. Additionally, there is a focus on establishing comprehensive systems for remote control of large-scale loading and unloading facilities, management of bulk cargo yards, intelligent gateways, and vessel scheduling, to enhance the automation level of port production operations .

Building upon existing infrastructure, efforts are directed towards the systematic advancement of the Digital Operation and Control Platform (OCC). In addition to functions such as real-time tracking of container movements, automated business monitoring and alerts, and intelligent operational statistics, the OCC platform is being enhanced to integrate disparate port business systems, effectively linking port production operations with dispatching, navigation, railway, and other supporting services. Moreover, the platform is being adapted to address new business scenarios, leveraging unified data access, data governance, and service openness capabilities, to aggregate data from operational lines and ecosystems, extract management insights, and achieve lean production and precise services in port production systems.

To fully leverage Singapore's central position and role in the entire maritime transportation system, efforts are underway to encourage freight and agency companies to enhance their formalization and intelligent transformation. This involves guiding these companies to develop digitized operational systems for logistics transportation, enabling real-time monitoring of transportation equipment operation information and technical status, and achieving remote visualization monitoring and dynamic management of transportation equipment. Furthermore, the construction of customer analysis and precise marketing systems is being pursued, utilizing customer profiling and tag models to facilitate intelligent demand matching based on customer characteristics. Overall, with Singapore Port at its core, initiatives are aimed at leading and driving global maritime transportation systems through formalization, thereby enhancing operational efficiency and customer service precision.

6. Conclusion

As the world's second busiest port, Singapore Port serves not only as the operational core of PSA International Pte Ltd but also as a crucial hub connecting the Pacific and Indian Oceans. From its origins as an international trading port to its current status as one of the world's largest transshipment hubs, the development of Singapore Port has witnessed Singapore's economic boom and the prosperity of global trade. Its strategic geographical location makes it a vital intersection for maritime transportation, providing critical services for various ocean routes. The establishment and development of port management agencies continuously drive innovation and efficient operations at Singapore Port.

The success of Singapore Port is evident not only in its outstanding logistics and transportation capabilities but also in its role as a key center for industries such as electronics, petroleum refining, and shipbuilding. The global port operations of PSA further strengthen Singapore Port's pivotal role in global trade. Overall, the development of Singapore Port not only promotes Singapore's prosperity but also makes significant contributions to the global economy and trade system. Its efficient and innovative operational model, coupled with its excellent strategic geographical location, sets it apart on the international shipping stage. The success of Singapore Port serves as a valuable lesson for other ports and countries, emphasizing the importance of ports in the era of globalization and highlighting the need for continuous innovation and sustainable development in port management.

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