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Why Efficiency Gains Do Not Guarantee Economic Power: How Port Automation Affects Bargaining Dynamics in the Marine Trade Industry

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Port automation is transforming global maritime trade, yet its effect on the balance of bargaining power between ports and shipping alliances remains unclear. Using Shanghai Yangshan Deep-Water Port as a case study, this essay examines how automation-driven efficiency gains interact with market structure to shape port bargaining power in the short and long run. Ports operate in a moderately competitive, technology-intensive market, while shipping alliances form a tight oligopoly that controls the majority of global container capacity. In the short run, automation lowers costs and concentrates traffic at early-adopting ports, temporarily strengthening their negotiating position. However, as automation diffuses industry-wide, cost advantages erode, competition intensifies, and involution sets in: throughput rises while per-unit margins stagnate. Consequently, the surplus generated by efficiency gains increasingly accrues to shipping alliances rather than to ports. The essay concludes that automation alone does not guarantee ports greater economic power, and proposes two countervailing strategies, deliberate service differentiation and coordinated capacity planning among ports, or the formation of a unified national shipping alliance, while acknowledging the practical limitations of each.

Keywords: port automation, bargaining power, shipping alliances, oligopoly, marine trade, Yangshan Port

Stakeholder Analysis Within the Marine Trade Industry

For centuries, marine trade has gone through four different periods (Stopford, 2009): the Age of Sail, before 1815, when marine transport led by colonial companies mainly relied on wind-powered vessels via traditional shipping routes; the Age of Steam (1815-1950), during the industrial revolution, when the liner services system was adopted; the Age of Diesel & Bulk, from 1950 to 1973, when diesel power replaced steam engines with the rise of diesel-driven bulk carriers and specialized tankers (UNCTAD, 2023a); and the Age of Containerization, which began after 1973, when intermodal containers were universally adopted, rigid liner conferences were dissolved, and global shipping alliances were formed. By 2024, the world's top five container shipping lines held 68% of the global market share (Alphaliner, 2024).

Marine trade has enlarged its economic role. In the 1970s, maritime transport accounted for about 70% of global merchandise trade by volume (UNCTAD, 2025a), while continuously supporting over 80% of cross-border goods circulation worldwide, accounting for about 70% of trade value (UNCTAD, 2025b; 2025c). In

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addition, the marine trade industry is more globalized. Over the years, the marine trade evolved from regional exchanges of goods to the global circulation of merchandise. The Liner Shipping Connectivity Index (LSCI) rose from 0.143 in 2004 to 0.241 in 2024, reflecting a substantial densification of the global maritime trade network (UNCTAD, 2024). Centralization is another trend in the marine trade industry. More than 84% of the global container capacity is controlled by the Top 10 container shipping lines in the world, with the Top 3 giant shipping companies, MSC, Maersk, and CMA CGM, controlling over half of the total capacity (COSCO Shipping, 2024). About 48% of global container traffic is handled by the Top 10 container ports worldwide, including Shanghai International Port Group (SIPG), PSA International, and Ningbo Zhoushan Port Co., Ltd. (Drewry, 2025; SIPG, 2025; PSA International, 2025).

Within the tightly interdependent ecosystem of marine trade, buyers, sellers, ports, and shipping alliances are key stakeholders. Buyer and seller markets are most competitive, with CR4 ≈ 10% (Drewry, 2024a), resulting in the weakest bargaining power and the lowest profit shares. This analysis focuses solely on ports and sellers for two key reasons. First, buyers and sellers in the maritime trade market are highly fragmented, lacking the scale to determine their influence on profit distribution. Second, they are not the core transportation hubs of marine trade that participate in the core bargaining game. Ports face moderate competition, with CR4 ≈ 65% (World Port Index, 2024), resulting in weaker bargaining power than shipping alliances, whose CR3 is 81.4% (Alphaliner, 2024), holding the strongest bargaining power for larger profits.

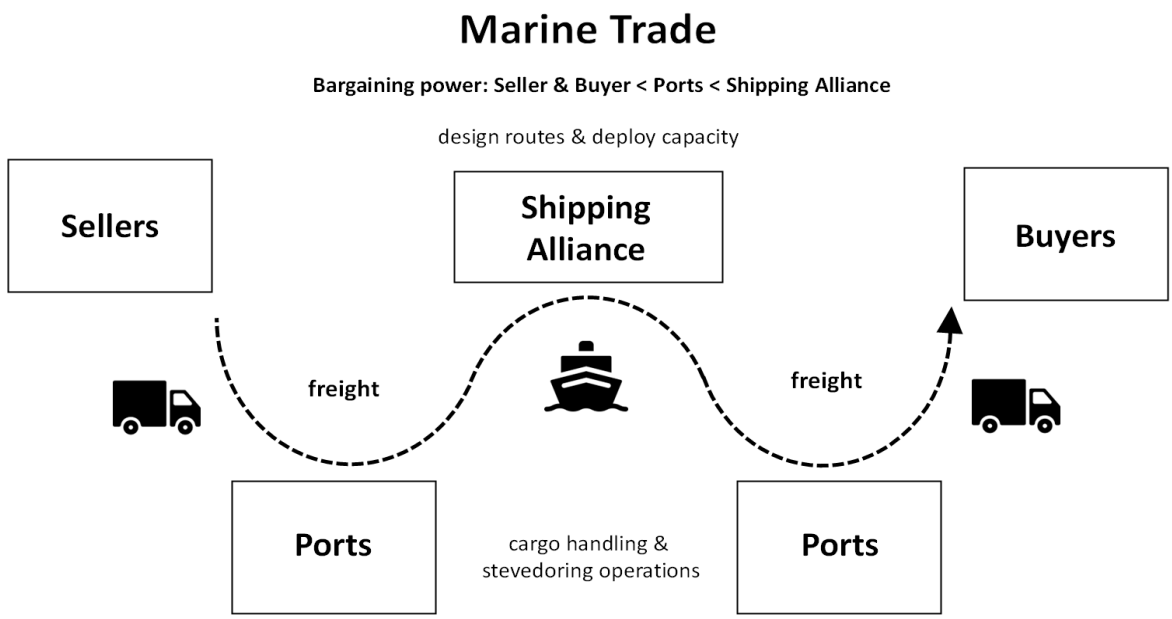

Figure 1. Stakeholder structure and bargaining power hierarchy in the marine trade industry.

Bargaining Power of Ports

Shanghai Yangshan Deep-Water Port, as a core component of Shanghai Port, operates within an oligopolistic market structure characterized by three core features: technology-intensive operations with high entry barriers, industry concentration among a few dominant ports, and limited pricing power due to government regulation.

Since the mid-2010s, Yangshan has invested heavily in automation, including automated guided vehicles, remote-controlled quay cranes, and AI (artificial intelligence)-based Terminal Operating Systems, increasing container handling efficiency by approximately 50% (China Today, 2025). Capital costs required to build a new

port facility create high entry barriers to new competitors (The World Bank, 2007). Also, the high capital investment in automation means existing ports face substantial sunk costs to replicate these infrastructures, thereby consolidating Yangshan's competitive advantage. Moreover, the Port of Shanghai handled 55.06 million TEUs in the year of 2025 (Si, 2026), and together with the Ningbo-Zhoushan, Shenzhen, Qingdao, and Guangzhou ports, they handled 43, 29.3, 27.6, and 22.8 million TEUs, respectively (Rahman, 2025). Together with a nationwide container throughput of 324.7 TEUs, the five ports' concentration ratio exceeded 50%. However, Yangshan Port operates in a market with limited pricing power (Merk, Kirstein, & Salamitov, 2018). Port fees are strictly regulated by the Ministry of Transport and the National Development and Reform Commission (2019), constraining Yangshan's pricing power and forcing revenue growth to depend on throughput volume rather than price increases. This positions Yangshan as a bounded price maker in the market, where its profit margin expansion is limited by the price elasticity of demand.

In China's coastal port network, Ningbo-Zhoushan Port poses the greatest domestic challenge to Yangshan. With 35.30 million TEUs in 2025 and an 8.2% growth rate, higher than that of Shanghai (Bruno, 2025), it leverages superior natural endowments: 280 kilometers of deep-water coastline accommodating 300,000-ton vessels without tide restrictions, compared to Yangshan's 15.5-meter water depth limitation (Ningbo Municipal People's Government Port Office, 2015). More critically, Ningbo-Zhoushan's remote-controlled crane cluster, with an over 50% remote operation rate, directly competes with Yangshan's Phase IV automated terminal (Ghadialy, 2025). The intensifying competition undermines Yangshan Port's bargaining power, forcing Yangshan to offer more competitive terminal handling charges and service terms to retain customers.

On the international stage, Yangshan Port competes with Singapore Port. With 44.66 million TEUs in the year of 2025, Singapore port dominates transshipment, accounting for 90% of its cargo, leveraging its strategic location in the Malacca Strait. Singapore's Tuas Mega-Port, scheduled for completion by 2040, will double its capacity to 65 million TEUs (Port of the Future, n.d.). In response, Yangshan is accelerating its Phase V automated terminal to increase its cargo handling capacity and will integrate with the Shanghai Free Trade Zone to offer bonded transshipment services, narrowing the gap in policy flexibility. Next, the geopolitical and network advantages of both ports further intensify the rivalry. Singapore has signed bilateral trade agreements with 12 Southeast Asian countries to streamline customs clearance (Medina, 2023), while Shanghai leverages the Belt and Road Initiative to strengthen ties with ports in the Middle East and Europe (International Services Shanghai, 2024), diverting part of the transshipment cargo that previously flowed through Singapore. The competitive dynamics between Yangshan Port and Singapore Port reveal key implications for Yangshan's bargaining power in global maritime trade. Singapore's unrivaled transshipment dominance limits Yangshan's leverage with shipping alliances, demonstrating that alliances hold the upper hand in negotiating port terms, further weakening Yangshan's ability to secure stable transshipment volume. Moreover, the unstoppable rise of cargo handling in both ports means that Yangshan must continuously invest to avoid losing long-term bargaining power on the China-Europe route transshipment.

Bargaining Power of Shipping Alliance

Shipping alliances are partnerships among ocean carriers that optimize their operations. Carriers no longer operate in isolation; they now pool their resources to achieve efficiency gains. This aspect affects freight rates, transit time, and service reliability for global trade. The underlying principle of resource pooling is vessel-sharing agreements (VSAs), legal contracts that allow carriers to jointly operate liner services on certain routes with a

specified number of vessels (Panayides & Gong, 2002). This arrangement enhances service coverage without the need for individual fleet expansion (Notteboom, 2004). For example, a VSA allows a carrier that has enough ships for only three routes across the Trans-Pacific to operate nine routes through partner exchanges, as members combine their fleets into a coordinated network. This arrangement is especially important, as operational costs account for more than 67% of total costs incurred by shipping lines, with bunker costs (46%) and port charges (21%) as major variable costs that can be minimized through shared operations (World Bank, 2022). According to the United Nations Conference on Trade and Development (UNCTAD, 2018), consolidation through alliances enables companies to combine their resources and enhance efficiencies. In this context, larger lines optimize their assets, while smaller carriers achieve extended coverage without the need for fleet investment.

The container liner shipping industry exhibits clean oligopolistic characteristics, defined by high concentration ratios and strategic interdependence among a minimal number of dominant firms. Industries with a four-firm concentration ratio (CR4) of 40% or higher often qualify as oligopolies, as each player must anticipate competitors' reactions (Shepherd, 1999; Schmalensee, 1989). More classifications distinguish between loose oligopolies (CR4 of 25-60% with moderately easy entry) and tight oligopolies (CR4 exceeding 60% with significant barriers to entry), where market conditions facilitate sustained supernormal profits (Shepherd, 1999; Sys, 2010). The Top 4 largest shipping companies' market shares in 2025 are MSC 21.4%, Maersk 13.8%, CMA CGM 12.4%, and COSCO Shipping Lines 10.7% (Alphaliner, 2026). Thus, the industries' CR4 should be 58.3%, indicating an oligopoly and close to a tight oligopoly. The barriers to entry are also significant. MSC and Maersk have port capacities of 7,190,439 TEUs and 4,622,975 TEUs, respectively; the Top 8 largest shipping companies worldwide all process more than 1,000,000 TEUs (Alphaliner, 2026). With the most efficient routes and port partnerships already locked by these companies, this amount of port capacity would be impossible for small firms to compete with.

Evaluation of Bargaining Power of Ports and Shipping Alliance

The balance of bargaining power in the marine trade industry is mainly shaped by five factors: geographical necessity, technological and operational efficiency, financial strength and scale, market structure, and regulatory and environmental constraints. Ports at irreplaceable locations, such as global shipping chokepoints, often have stronger and more stable bargaining power than the rest. Ports like Port Said and Port Suez, located at the two ends of the Suez Canal, maintain a 95% vessel call rate from major shipping alliances, while non-chokepoints in the eastern Mediterranean have a 62% call rate (UNCTAD, 2023b). Additionally, advanced loading systems enable ports to deliver goods more efficiently, thereby enhancing their bargaining power. Quay crane efficiency reached 60.2 TEU/hour, increasing its vessel berth rate by 22% YoY (Deloitte, 2024). Furthermore, ports with large-scale infrastructure attract more shipping alliances and receive long-term contracts, thereby increasing their bargaining power. Ports with over 15 million TEU annual throughput signed 42% more long-term contracts with shipping alliances (Drewry, 2024b). Besides, when ports consolidate into alliances, their market becomes less competitive. In the Mediterranean shipping market, the Top 3 port alliances control 68% of regional container throughput, while independent small ports account for only 12% (Notteboom, Pallis, & Vaggelas, 2024). Lastly, port-enforced environmental rules for shipping alliances, such as ECA Low-Sulfur Fuel Compliance Checks, impose restrictions, making ports with these policies less attractive to shipping alliances. Alliances reduced calls at strict-ECA ports such as Hamburg and Antwerp, resulting in an 8%-10% decrease in container volumes (Xiao, Wang, & Zhang, 2025). The other example is when the EU enforced onshore power supply (OPS) policies, its market share of small and medium-sized ports dropped by 12% YoY (Notteboom, Rodrigue, & Slack, 2023; European Commission, 2022).

In the short run, automation can temporarily strengthen a port's bargaining position by reducing costs and creating business-stealing effects. By reducing labour input and increasing output through improved productivity, the automation of port operations will enhance the performance of early adopters, giving them an advantage over competing ports (OECD/ITF, 2021). For example, Yangshan Phase IV reduced its on-site workforce by approximately 70% while increasing overall operational efficiency by about 50%, with labor productivity more than doubling relative to traditional terminals (State Council of the PRC, 2024). With fewer employees and processing a higher volume of cargo, highly automated terminals generally will earn much larger profit margins than less automated ports until similar technologies have been adopted by other ports (OECD/ITF, 2021). Until other ports adopt similar levels of automation, the lower costs associated with adopting these technologies will elevate the reservation profits of very high-output ports but also create a lesser urgency to give in to aggressive fee demands from global shipping alliances (Merk et al., 2018).

Additionally, traffic flows into ports can be increased in the short term through automation. Shipping alliances are focused on reliability, economy of scale, and fast turnaround time (Merk et al., 2018). Highly automated ports are seen as optimal routing options, and as traffic flows to high-conveyor-capacity terminals, ports will benefit from a short-term increase in market share and throughput, thereby strengthening their position within the global shipping logistics system (Shanghai Municipal Government, 2025). Yangshan Phase IV alone has handled over five to six million TEUs annually, and Shanghai's 50-million-TEU annual throughput milestone was achieved at this automated terminal (Shanghai Lingang Administrative Committee, 2024). Increased concentration of traffic reduces substitutability, making it less likely that alliances will reroute large volumes of cargo away from a dominant hub. This will weaken the likelihood of successful rerouting and improve the ports' ability to negotiate successfully (Merk et al., 2018).

Together, these cost and concentration effects explain how automation can temporarily enhance a port's bargaining power. However, this advantage is inherently unstable and highly dependent on other ports' strategic actions. As innovation diffuses across the industry and efficiency becomes the baseline, cost differentials narrow and substitutability increases, eroding the short-run gains in bargaining position (OECD/ITF, 2021).

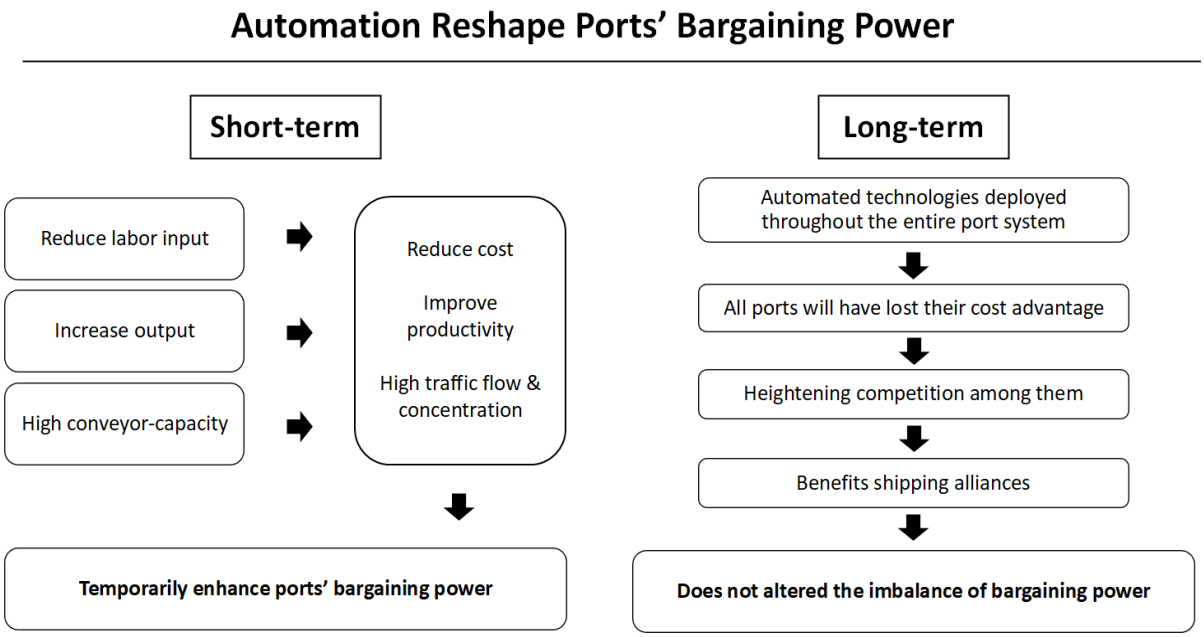

Figure 2. Short-run and long-run effects of port automation on ports' bargaining power.

In the long run, it is doubtful that ports operating in a near-perfectly competitive market will find additional profit from automation technologies. While the implementation of automation does result in increased efficiency, once automated technologies are deployed throughout the entire port system, all ports will have lost their cost advantage, thus heightening competition among them (OECD/ITF, 2021). Port automation is no longer limited to a small number of experimental terminals but has spread to major ports across Asia, Europe, and North America, becoming a standard feature of new terminal development. As automated technologies are introduced globally, the first-mover advantage will diminish, leaving them as the baseline standard against which all ports will operate. Therefore, over time, all major ports will converge on a similar cost structure and achieve a closed level of operational capacity, removing their ability to exert pricing power over competitors. Where all major ports have equal levels of efficiency due to an equal cost structure, competition will be forced to take place predominantly within the low end of the port service price range.

This dynamic contributes to involution within the port industry. While ports continue to automate and add on capacity in order to maintain their market share, the total volume and/or total throughput increases without any corresponding increase in revenue per unit; in essence, ports handle more containers but earn little more per container, thus causing a decline in overall margins over time despite increased efficiency. For example, major ports have reported record TEU growth over the past decade while per-unit handling charges remained largely stable (Merk et al., 2018). Due to increasing competition at the volume rather than the price level, excess capacity will continue to rise, exerting downward pressure on the rates charged for port services. Under these conditions, the benefits from increased efficiency will be passed on to customers through lower market prices, rather than retained by the vendor as profits.

At the same time, surplus distribution increasingly favors shipping alliances. The container shipping sector is highly concentrated, with a few global alliances controlling most vessel capacity on the major trade routes. Three global shipping alliances control approximately 90-95% of capacity on major East-West trade routes (Merk et al., 2018). These alliances hold significant bargaining power in negotiations with ports over the service portion of the benefits created by the automated port-shipping system, unlike individual ports, which face intense competition among themselves and a very limited ability to differentiate their services, leaving them as price takers in a competitive environment.

The port-shipping system has become increasingly efficient through automation. However, automation has not altered the imbalance of bargaining power in the port-shipping system, as the majority of the benefits generated by automation will continue to accrue to the shipping alliances (Merk et al., 2018). In the long term, the efficiencies in the shipping and port systems will continue to increase, and ports' profitability and pricing power will remain dependent on ongoing relationships with the shipping alliances.

Suggestion

The narrowing TEU gap (19.76 million), combined with Ningbo-Zhoushan's faster 8.2% growth rate versus Shanghai's 6.9%, signals diminishing market dominance, reducing Yangshan's leverage with cargo owners over Yangtze River Delta fees. Since automation has reduced the costs associated with port handling, shipping alliances can leverage these savings, as well as shorter turnaround times, through collective bargaining and the threat of rerouting vessels (Merk et al., 2018). Shipping alliances are thus in a position to capture a significant share of the hinterland that now has viable alternatives. Furthermore, technological parity neutralizes Yangshan's automation advantage. Ningbo-Zhoushan's 72% remote-operated crane cluster directly rivals Yangshan's Phase

IV terminal, preventing premium pricing based on efficiency (China News Network, 2025). The competition for bulk cargo, with Ningbo-Zhoushan capturing a larger share of crude oil terminals and iron ore capacity, further fragments Yangshan's customer base. To restore bargaining leverage, Yangshan must pursue differentiation through deeper integration with Shanghai's free trade zone ecosystem and specialized high-value-added cargo services.

Differentiated Individual Ports

The first strategy of differentiation is deliberate differentiation by individual ports. While it may be difficult for ports to quickly replicate a specific differentiation strategy, there are many dimensions of operational specialized services that are important to shipping alliances. These include tiered levels of service reliability, delivering faster or more efficient results, as well as operational specialization by cargo type (e.g., refrigerated containers, hazardous materials, transshipment, etc.). It also includes tiered service reliability, where certain services guarantee faster or more predictable turnaround times. Customized digital services that align directly with carriers' logistics systems can also help a port differentiate itself from others. While these new methods of differentiation will not eradicate competition between ports, they will increase the costs and risks of substitution, thereby reducing shipping alliances' ability to pressure ports into lower fees and improving ports' bargaining positions. Another differentiation may be achieved through increased coordination among ports, thereby reducing unsustainable, destructive competition between individual ports. Directly responding to competitive pressures, many ports have pursued similar objectives of automating and expanding capacity, with the unintended result being the threat of continued excess capacity within the industry.

By coordinating capacity expansion plans, especially among identical regions (i.e., neighboring), ports can avoid the risks of continued excessive capacity. Coordinating the development of common automation and technical standards enables ports to realize the same levels of efficiency without redundant overinvestment in automation and technology. Because of this ability to address excess capacity through coordinated planning, price competitiveness between shipping alliances and port operators stabilizes, strengthening the overall bargaining position of ports as a group relative to shipping alliances.

However, deliberate differentiation and coordination among ports face important limitations. First, differentiation strategies may be costly and unevenly effective, as not all ports possess the geographic, infrastructural, or financial conditions required to specialize in high-value cargo types or advanced digital services. Second, whilst shipping alliances may be able to provide cooperation between terminals, the shipping alliance may not want to invest in their own digital port systems to not impact their operational flexibility or incur substitution costs. Second, coordination among ports is difficult to implement in practice. Ports often operate under different ownership structures, regulatory regimes, and competitive mandates, which constrain their ability to coordinate capacity expansion or investment decisions. Concerns about reduced competition or regulatory intervention may also arise from excessive coordination, especially if it restricts market forces. As a result, while differentiation and coordination can mitigate destructive competition, they are unlikely to fully offset the structural bargaining power of shipping alliances and must be viewed as partial rather than complete solutions.

Establish a National Shipping Alliance

The second strategy is establishing a unified Chinese national shipping alliance. Currently, the global shipping industry is dominated by three major oligopolistic alliances (2M, Ocean Alliance, and THE Alliance), which control over 80% of global container throughput and hold significant bargaining power over ports (Drewry,

2024c), establishing a Chinese national alliance consolidating domestic shipping companies into a powerful single, large-scale entity, strengthening the global market power of Chinese fleets, and thus increasing reciprocal leverage: When foreign shipping alliances attempt to extract more profit from Chinese ports, the Chinese national alliance can retaliate by diverting its vessels away from foreign ports.

But there are also some problems. First, since a united national shipping alliance would create a dominant player in the Asia-Europe and transpacific trade lanes, the alliance could face heightened antitrust scrutiny from global regulators, leading to fines or forced divestments. Second, large, centralized alliances would lose the flexibility to adapt quickly to shifts in market demand, reducing China's ability to respond to dynamic global shipping conditions, and they may also encounter diseconomies of scale as their throughput increases. Thirdly, forming a national shipping alliance would conflict with the existing long-standing partnerships that many domestic shipping firms maintain with the 2M, Ocean Alliance, and THE Alliance, such as COSCO Shipping Lines. A national alliance would force them to choose between these partnerships and domestic alignment, potentially fragmenting their global network and reducing access to key foreign ports and trade routes.

Conclusion

Automation has accelerated as ports compete to attract shipping alliances by improving efficiency, reducing turnaround times, and lowering operating costs. While these investments clearly improve operational performance, they do not guarantee stronger profitability or bargaining power for ports. In an environment characterized by intense inter-port competition and high buyer concentration among shipping alliances, efficiency gains are often competed away rather than captured. This essay shows that automation can strengthen port bargaining power only in the short run, when early adopters benefit from temporary cost and performance advantages. Over time, however, as automation diffuses across the industry and becomes the standard, these advantages erode. Ports converge toward similar cost structures and operational capabilities, leading to involution, margin compression, and limited pricing power. As a result, the long-run benefits of automation accrue disproportionately to shipping alliances, which retain strong bargaining leverage and capture much of the surplus generated by lower logistics costs.

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