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Why Port Automation Generates Conflict in Some Economies but Stability in Others: A Comparative Institutional Perspective Between China and the US

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Abstract. Over 80% of global commodity trade relies on seaborne transportation, with container ports serving as pivotal hubs connecting upstream and downstream supply chain segments. Driven by surging maritime shipping demand and the pursuit of operational efficiency, intelligent port automation has evolved into an irreversible global trend. Though both China and the United States have promoted port digital upgrading, they adopt divergent reform paths, confront unique institutional dilemmas, and generate vastly different practical outcomes. This essay conducts a comparative case study focusing on Shanghai Yangshan Port and Los Angeles Port. It contrasts the implementation effects of automated transformation and corresponding labor relations systems in the two economies, and further explores the institutional, cultural and regulatory roots behind their performance gaps. The analysis reveals that the Chinese port operation framework achieves prominent advantages in handling efficiency and supply chain stability, while its hidden drawbacks in worker welfare and employment equity are also discussed to deliver balanced conclusions and targeted policy suggestions.

Keywords: port automation, labor relations, institutional comparison, container terminal, industrial conflict

1. Introduction

1.1. Automated ports are an unstoppable trend

The influence of automation on port efficiency is exemplified by Yangshan Port's Phase IV terminal, which began operations in December 2017. In seven months, it achieved a daily throughput of more than 10,000 TEUs [1], laying the foundation for efficiency gains. By 2025, after the implementation of the ITOS system, Yangshan Port had handled 28.706 million TEUs, which is triple the volume of the Port of Los Angeles at 10.20 million TEUs [2, 3]. Furthermore, it has kept competitive ship-to-shore speed at just 1.2 days for a vessel to berth and discharge, compared with 1.4 days in Los

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Angeles [4]. According to the Container Port Performance Index 2020-2024 [5], the Yangshan Port was ranked first in global maritime trade. The key to success is the ITOS intelligent control system, which has transformed the port from a labour-intensive to a capital-intensive system, saving an average of 2 hours per ship and stabilising berth utilization at around 84% [6]. Therefore, Yangshan Port is a typical case that illustrates how automation advances both productivity and large-scale operation in modern ports.

Port automation has changed from being a competitive advantage to a survival need. Inefficient logistics links bring risks and costs along the global supply chain, forcing all stakeholders to automate. Upstream pressure will be passed through to the downstream. Maersk is an example that uses APIs and EDIs to enable fast, secure data transfers, automatically updates information in real time, and requires its port partners to use real-time data connectivity. Similarly, Port 4.0, from managing to orchestrating, enhances the efficiency and resilience of the shipping network, indicating that the real value of a port lies in its dockage fees and other measures to improve system-wide efficiency and resilience. High levels of automation and digitization have become a core comparative advantage in the marine trade system.

However, automation has reduced the number of dockworkers since the 1960s [7]. Conflicts between machines and labor are not merely historical but are exaggerate today. In 2025, the Port of Long Beach would have faced workforce transitions due to more than 1,000 dock workers , mainly driven by the substitution effect of machines. Likewise, port employers in Antwerp faced strong resistance from highly unionized labor when they attempted to push through disruptive automation [7]. Social friction arising from job displacement and union disagreement leads to temporary underemployment, constituting a direct efficiency loss. To assess the impact of automation on the labor market, a comparative perspective is essential. The experiences ofthe United States and China, representing two opposing poles of labor regimes, provide evidence.

1.2. The American approach to port automation

The challenge facing U.S. ports is exemplified by the Port of Los Angeles (LSA), as TraPac's Los Angeles terminal became the first facility on the West Coast to introduce automation, and LSA itself accounts for a large share of container volume in the US [8]. According to the CPPI, Yangshan Port ranks in the global top 5% for efficiency, while LSA ranks below the global top 300 across all vessel size groups [9]. Additionally, LSA's total port hours per ship are about 55-60 hours, while those of Yangshan Port are 20-25 hours [9]. That evidence illustrated that Yangshan Port is more efficient than LSA Port. Such under-performance is not an isolated case but reflects a regional trend. North America had the lowest CPPI scores in 2022, while Asian ports accounted for half of the Top 20 [9]. Such performance raises trade costs and underscores the nation's port efficiency.

The U.S. Ports face an explicit strike conflict over automation, epitomized by the 2024 International Longshoremen's Association (ILA) strike at East Gulf Coast ports [10]. The work stoppage lasted three days and disrupted 35% of U.S. trade [11]. $2 billion in daily cargo flow had stalled [12], and 45,000 port workers refused to work [11]. Though an increasing wage mitigated the drag, the core dispute: ILA's demand to ban port automation remains unresolved [10]. The explicit conflict harms both short-term operations and long-term efficiency.

American labor conflicts are deeply related to the nation's individualism and democratic ethos. Individualism emphasizes self-reliance and the primacy of personal autonomy. "Americans do not like to depend on other people. They do not like owing them, needing them, or being beholden to them … In a word, they want to be free. Freedom means having to answer to only yourself" [13]. These thoughts show why workers resist automation, as it threatens their livelihoods and decreases

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the demand for labor. The explicit conflict also aligns with democracy. According to Gordon's analysis in the Berkeley Undergraduate Journal, American democratic culture has the core belief that "my voice should be heard," regardless of differing ideals [14]. Habermas, as cited by Gordon, argues that private rights, such as fair wages, must be fought for by workers in the public space, meaning that strikes are a way workers use to protect their democracy and individualism.

Another explanation of the conflict in U.S. port automation is the misalignment between port owners ' profit-driven objectives and labor's focus on job security and fair compensation. Private port owners prioritize cost reduction and productivity gains as their core motivations for automation, as automated equipment can lower long-term labor costs and minimize input [15]. In contrast, workers' incentives revolve around safeguarding livelihoods. Automation reduces labor demand by 40-50%, threatening workers' jobs. In addition, dock workers' resistance is amplified by firms ' limited willingness to share the benefits of automation. Unlike some global ports that offer retraining for affected workers [15], the misalignment and ignorance of the affected labor in American ports causes conflict. Consequently, many American ports suffer from low efficiency when dock workers go on strike, significantly reducing the labor supply, making it impossible to finish work on time. The strike shut down 36 U.S. ports, significantly disrupting U.S. and international supply chains. It is estimated that the strike costs the U.S. economy around $5 billion a day [16].

Tied bargaining power also contributes to overt resistance, as the labor union does not fear the ports' power and is determined to prevent automation. Labor unions are empowered to mount sustained resistance against automation. The 2025 ILA contract underscores how unions ' bargaining power shapes U.S. port labor conflicts. The President of LFA, Harold Dagget, led the action against automation. The ILA successfully used 85,000 members ' collective power to access a six-year contract: a 62% wage increase and full protections against automation. This success stems from the union's ability to mobilize labor while disrupting ports and even the country. Furthermore, the ILA expanded its influence globally. The 2025 Lisbon Summit, attended by more than 1000 workers, spearheaded the formation of the Global Maritime Alliance aimed at preventing port automation worldwide [17]. As Dennis Daggett framed it, this unity views port automation as a "job-killing technology", transforming local bargaining into a global force [17] capable of opposing automation worldwide.

2. The Chinese approach to port automation

The port automation process in China differs from the US. Automation in the US amid adversarial labor-management negotiations. Unions use strikes to claim compensation, thereby prolonging the disputes and delaying project implementation. In contrast, Chinese state-owned ports have taken the policy-driven route of workforce adjustment. The Ministry of Human Resources and Social Security launched the "Vocational Skills Improvement Action" in 2019. By 2021, it will have trained and certified 83 million workers [18]. To carry out the initiative, the Unemployment Insurance Fund distributed 64.6 billion yuan to 11.2 million enterprises in 2022 [18]. Port owners can use subsidies to retrain laid-off workers, contributing to a blue-to-white-collar shift. For example, Yangshan Port tower crane operators have changed from working on tower cranes to working in the office after retraining. This narrative of workforce transformation, however, tells only part of the story.

While the policy-driven adjustment of the workforce protects formal employees, it remains weak for dispatched and outsourced workers, shifting automation risk from in-system to out-of-system employees. A basic question about the model's distributive justice raises. Specifically, Chinese port industries exhibit a significant dual employment structure, with non-Bianzhi (out-of-system)

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employees receiving starkly different treatment compared to Bianzhi (in-system) staff. Major port SOEs commit to protecting employees' employment rights within the system, but dispatched and outsourced workers still face precarious employment. Chinese law has strict regulations on labor dispatch, stating that "may only be practiced for temporary, auxiliary, or substitute job positions" [19]. So, port enterprises have increasingly used business outsourcing, which is legally defined as inter-enterprise commercial cooperation. Consequently, they can exempt the company from offering the same dismissal protections and economic compensation to out-of-system workers.

Technological upgrades have reduced the proportion of dispatched workers. Low-skilled employment groups have been affected more than high-skilled groups, but the impact on in-system employees is relatively small [20]. This substitution effect is more prominent in SOEs . Given that port SOEs have ownership and employment practices similar to those of manufacturing SOEs, this conclusion also applies to ports. Automation first replaces the workers with lower skills and looser labor relations, which is exactly where the out-of-system employees are gathered. Nationally, the scale of this unprotected group is huge. According to data from the Ministry of Human Resources and Social Security, among approximately 459.31 million urban employed persons in 2022, about 238.4 million were covered by unemployment insurance, leaving about 48% of the urban employed population uncovered. The number of out-of-system workers accounted for a large proportion [21]. These figures indicate a clear line of demarcation in the cost internalization of Chinese ports. Automation costs can be effectively internalized into the enterprise within the system (employees), and costs are allocated through joint efforts by the enterprise, government, and society. Although port SOEs seem to have achieved the goal of a "smooth transition," the employment effects of automation do not disappear but are transferred to the most disadvantaged workers, creating a hidden social cost under this model. To understand these limitations, it is necessary to assess the cultural, institutional, and labor relations factors that maintain this model.

2.1. China model wins in efficiency but may not be replicated

The efficiency gains from China's automation model are substantial. With the continuous advancement of automation, the impact it has on the labor market is an inevitable issue. "In the past year, after installing sophisticated automated equipment, the number of human factory workers had fallen from 3,500 to about 1,800" [22]. This is an actual event that occurred in Shanghai. It forced employees to search for new jobs. However, reducing employees does not necessarily mean a decline in overall efficiency. The practice at Qingdao Port shows that, while staff allocation was reduced by approximately 15%, operational efficiency increased by about 20% , because automation increases equipment utilization and operation accuracy. Moreover, the transfer of the labor force is more reflected in the transformation of job nature rather than the simple disappearance. At the Meishan Port, 145 remote-controlled quay crane operators are controlling 36 quay cranes from an indoor control center, shifting their work from physical labor to system operation and management [23]. The refinement of labor skills creates the potential for long-term growth in labor productivity. These operational successes demonstrate the model's surface-level advantages. Understanding why this model works requires examining the deeper institutional foundations that enable such smooth transitions. Three mutually reinforcing pillars underpin this cost internalization mechanism: cultural endowments, institutional incentives, and labor relations.

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2.1.1. Cultural endowments

One reason is a specific cultural endowment that shapes labor-capital relations and provides a socio-psychological basis for the institutional setup. The primary socio-psychological basis of Chinese collectivist culture differs from that of Western culture, which stresses individual rights and contract relations. In Chinese culture, individuals emphasize the interdependence of the individual and the group, even in some cases, the individual has to give way to the group. A study shows that SOE employees usually have a stronger psychological contract than their counterparts in private and foreign firms [24]. Given that the fulfillment of the psychological contract has been robustly established as a key antecedent of organizational commitment in the empirical literature [25], this helps explain why higher organizational loyalty is often observed among SOE staff. This stability reduces the risk of human capital investments and labor-capital conflicts. In addition to collectivism, Paternalistic culture also forms another part of cost internalization. Paternalistic leadership in Chinese enterprises includes three dimensions: benevolent, moral, and authoritarian leadership, in which benevolent leadership emphasizes personal care for subordinates [26]. In the automation process, paternalism is expressed as job security commitments. Besides, developmentalist ideology gives technological progress legitimacy. Since the reform and opening-up, economic development and technologically modernized have always been put on top of the agenda. Port automation is contained in the national strategy of "building world-class ports", "strengthening transportation infrastructure", etc., and the government explicitly encourages "promoting intelligent development of ports" [27]. These three cultural factors at different levels facilitate cost internalization. Collectivism lowers the individual resistance; paternalism gives firms legitimacy; developmentalism gives states legitimacy. But this will not be tension-free. While paternalistic leadership can enhance employee loyalty [26], Aycan cautions that it may reduce subordinates' autonomy and create high dependency, contradicting the adaptive capabilities needed in automated work environments. More fundamentally, the continuity of its underlying cultural foundations during an intergenerational shift in the workforce is a pivotal uncertainty [27].

2.1.2. Institutional incentives

Although cultural traditions lay the socio-psychological basis for the internalization of costs, it is institutional incentive mechanisms that truly promote the realization of this model. The political tournament and the consequent subsidy together shape cultural norms into a set of behavioral constraints. China's political system features a political tournament. Chinese local officials are usually under pressure to promote economic growth, but in recent years, the assessment system has placed greater emphasis on employment rates and social stability [28]. In 2019, the State Council launched the "Vocational Skills Improvement Action", and in 2025, the Ministry of Transport also proposed the idea of "handling the relationship between the construction of automated terminals and employment" properly. So, the government has been pushing for port automation to be more people-friendly. This guidance is implemented through subsidies, which can effectively shift some of the enterprises' automation costs to the public. The government provided 100 billion yuan from unemployment insurance fund surpluses for employee skill enhancement and job transfer training [27]. SIPG's 2021 annual report stated that it had received government subsidies exceeding 670 million yuan, indicating that a large amount of government financial assistance was provided to develop automation that year [29]. These subsidies lower automation costs for enterprises, making gradual automation with more friendly employment.

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2.1.3. Labor relations

The labor relation provides the third pillar to support cost internalization. There is a fundamental difference between Chinese labour unions and those in the West: the All-China Federation of Trade Unions (ACFTU) is lawfully characterized as an organization that "submits to the leadership of the Communist Party of China" [30]. It results in what Chen referred to as a "dual identity," that unions have to represent workers' interests and, at the same time, it has to carry out the party state's policy [31]. In contrast, the ILWU operates outside employer and government control and can retain its own organization to oppose management through collective bargaining and strikes. The labor disputes at the Chinese port differ. Chan and Hui talk about 3 stages for China's labor relations: "collective consultation as a formality," → "collective bargaining by riot" → "party state-led collective bargaining" [32]. Ports stay mostly at the first stage: formal consultation without real bargaining power, and sometimes state intervention (third stage) when tensions are high. The dispute resolution system is a dispute between individuals before they escalate into demands affecting a group. This will create "cellular activation", that is, labor disputes will remain within the enterprise boundary and be unable to form cross-workplace coordination [33].

Legal constraints add to this. The right to strike was deleted from the Chinese constitution in 1982 and has never been reintroduced [34]. The workers who organized collective action are now being criminally punished for Article 290 of the Criminal Law [35]. While Chan and Hui mention the 2010 Honda strikes as a rare case of "collective bargaining by riot", such events are rare in ports as state control is tight due to maritime logistics being strategically important [32]. Transportation and logistics workers accounted for a small share of labor protests in 2023, compared with manufacturing and construction [36]. The structure establishes a "preventive coordination" model for labor relations, thereby maintaining social harmony and stability. It does not allow workers to negotiate automation terms collectively as the ILWU does. As Friedman and Lee observe, the state has managed to create a "disorganized mass of individuals" who have been forced to deal with state and capital power on an individual basis, thereby maintaining the appearance of surface stability [37]. However, such suppression of a collective voice could build up tension that will come to the surface once the state's coordination ability weakens or the economy worsens.

In short, the Chinese port automation model presents a paradox: its efficiency stems from institutional foundations that are both its greatest strength and its fundamental limitation. The model wins in efficiency due to the synergistic interaction of cultural endowments, institutional mechanisms, and labor relations structures that enable smooth cost internalization. However, these same pillars make the model difficult to replicate in other contexts. The collectivist and paternalistic culture that fosters acceptance of automation contrasts sharply with individualistic values in Western democracies. The state-owned enterprise system, which provides massive capital and centralized coordination, is absent in market-driven economies. Most critically, the legal framework that constrains labor's bargaining power cannot be replicated in countries with independent labor movements and democratic traditions. While the Chinese model demonstrates how state coordination can overcome collective action problems and achieve rapid technological transformation, it also reveals the difficulty of transferring such approaches to contexts with different institutional arrangements. Understanding this paradox is essential for evaluating both the model's achievements and its broader applicability.

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3. Suggested policies

3.1. Extend protection eligibility to non-formal workers

The dual employment structure identified above requires institutional reform to extend protections beyond formal workers. Current mechanisms, including training subsidies, retraining programs, and unemployment insurance, primarily cover in-system employees but exclude dispatched and outsourced workers from this social safety net. Two reforms could address this gap. Local government performance evaluations should incorporate employment stability metrics for non-formal workers, creating incentives for officials to pressure enterprises toward protecting out-of-system employees. Fiscal support mechanisms, including tax breaks, low-interest loans, and training funds, should extend eligibility from formal employee transitions to non-formal worker retraining. SIPG received over 670 million yuan in government subsidies in 2021 [29], yet these funds primarily supported in-system workforce adjustment. Conditioning such subsidies on enterprises demonstrating protection for all affected workers, regardless of employment status, would align fiscal incentives with inclusive outcomes. This approach builds on existing mechanisms rather than creating new bureaucratic structures, reducing implementation costs while addressing the distributive inequities inherent in the current model.

This proposal faces three significant challenges. First, the cost implications are substantial. Extending protections to non-formal workers would increase enterprise expenses considerably, weakening competitiveness against Southeast Asian ports where labor standards remain low. Companies might respond by cutting jobs rather than expanding protections leading an outcome that would harm the workers the reform aims to help. Second, enforcement presents a major obstacle. Despite extensive labor legislation, enforcement in China remains weak. The prevalence of labor dispatch arrangements demonstrates how readily enterprises circumvent existing regulations. Without addressing enforcement capacity, new requirements will likely join the existing rules that companies routinely ignore. Performance-based evaluations for local officials may compound this problem by incentivizing statistical manipulation over actual protection. Third, political resistance seems inevitable. State-owned enterprises have long relied on differentiated employment systems to maintain core workforce stability while retaining operational flexibility through peripheral workers. Mandating equal treatment would disrupt this organizational model. Formal workers and their unions may also resist reforms that reduce their relative advantages, which they view as earned benefits rather than unjust privileges.

3.2. Compensation and skills fund

A complementary solution is to establish a targeted redistribution system at the national level to address the economic displacement caused by automation. China benefits from its massive, comprehensive infrastructure and highly automated, profitable ports, transforming those technological dividends into social security and stability because this combination generates a significant positive externality. Therefore, states could impose automation surcharges and set up a Compensation and Skills Fund as a precise transfer payment machine. Such a fund could be financed through many channels, including an appropriate surcharge on port operating fees or an allocation of a portion of corporate income tax revenue from the logistics sector. This fund could be structured around two core components: a compensation pillar provides a direct income support to displaced workers, and a skills pillar finances retraining programs. Besides, this fund would require a supporting digital platform to ensure precision. Such a platform would integrate data from port

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operators, labor departments, and social security systems to create a real-time registry of affected workers, track their transition status, and enable targeted disbursement of funds.

Inevitably, this model places significant demands on governance capacity, particularly in cross-departmental data sharing, sophisticated fund management to prevent misuse, and continuous impact assessment. Specifically, data is regarded as the "sovereign asset" and a reflection of performance of each department; data formats are different and hard to clean and compare; the huge volume of data collections brings heavy risks to privacy and security. Those factors limit the departments' motivation to share. Sophisticated fund management should establish standards to confirm who is affected worker and organize a transparent supervisory system to avoid misuse of fund and corruption; Finally, the critical question is whether retraining or redeployment are effective, or whether the affected workers just participate in simplistic, short-term training programs that fail to enhance their practical skills, thereby preventing them from securing high-quality employment. Nevertheless, this systemic approach represents a direct pathway to transform technological gains into social resilience, offering a potential model for managing industrial transformation with greater equity.

4. Conclusion

Different institutions affect labor relations and cost allocation methods, rendering internalizing, transferring, or externalizing costs. This moulds entirely different efficiency of automation. However, high efficiency does not mean no cost; instead, it is accompanied by unbalanced distribution among different groups. Consequently, automation is not a purely technological upgrading process, but a political-economic process, whose long-term efficiency depends on institutions' capacity to absorb and manage development transition costs while achieving automation efficiency.

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