1 Background and Literature

The rise of China's economy and deepening globalization have led to increased Chinese investments in global container ports, particularly following the Belt and Road Initiative (BRI) in 2013. China's strategic investments in overseas container ports, such as COSCO's stakes in Piraeus (Greece), Hambantota (Sri Lanka), and Gwadar (Pakistan), are reshaping the regional dynamics of global value chains (GVCs) by enhancing trade network integration, lowering transportation costs, and generating spatial spillover effects. These changes influence how GVCs reorganize spatially, creating both opportunities and challenges for regional economies.

Previous research on port development and regional economic growth has established several key theoretical frameworks. Early studies by Shan et al. (2014) used grey correlation analysis on 41 major Chinese port cities from 2003-2010, demonstrating that port throughput positively impacts the host city's economic growth. Chen (2019) extended this analysis by showing the interaction between maritime port cluster effects and offshore regional economic development. More recent work by Mudronja et al. (2020) developed dynamic panel models based on R&D-driven endogenous growth theory to analyze seaports' impact on regional economic growth.

The literature on Chinese overseas port investments has evolved significantly. Chen et al. (2019) identified five developmental stages in China's overseas port investment pattern: sporadic distribution, proximity-based layout, global diffusion, regional clustering, and overall stabilization. Liu et al. (2020) noted that the Belt and Road Initiative accelerated Chinese port investments, with investors favoring the "Port-Park-City" model. Dong et al. (2022) found that state-owned enterprises achieve larger market shares when investing in politically unstable regions with fewer ports.

Research on spatial spillover effects has gained prominence recently. Deng et al. (2020) found that coastal ports' comprehensive strength generates spatial agglomeration effects and regional differences. Han et al. (2019) used PLS and OLS methods to examine port spillover effects and logistics development's contribution to regional economic growth in the Beijing-Tianjin-Hebei region. Marquez-Ramos (2016) demonstrated that port development's spatial spillover effects have a greater impact on Spanish export growth than port facilities themselves.

2 Data and Sample

The analysis utilizes two distinct datasets. The port-level panel data covers 2006-2023 (quarterly) with 436 ports across Asia, Europe, and Africa. Key variables include Port Liner Shipping Connectivity Index (PLSCI), container throughput, and investment status, with control variables comprising trade volume, GDP per capita, population, FDI inflows, and political stability. The country-level panel data spans 2010-2022 (annual) with 99 countries, featuring national container throughput and investment status as key variables, alongside control variables including GDP per capita, population, logistics performance index, and natural resource rents. Data sources include UNCTAD, World Bank Database, Belt and Road Initiative official website, and annual reports of Chinese investing companies.

3 Methodology

In this research, the spatial difference-in-differences (SDID) model combines traditional DID methodology with spatial econometric techniques to analyze both the direct effects and spatial spillovers of Chinese port investments. The model relies on several key assumptions:

3.1 Parallel Trends Assumption

The fundamental parallel trends assumption of traditional DID must hold in the spatial context. This requires that in the absence of treatment (Chinese investment), the trend in port connectivity and container throughput would have been similar between treatment and control ports over time. We verify this assumption through event study analysis, examining pre-treatment trends between invested and non-invested ports. The model specification includes port-fixed effects (u_i) and time-fixed effects (v_t) to control for time-invariant port characteristics and common time trends, respectively.

3.2 Spatial Independence of Treatment

The treatment assignment (Chinese investment decision) for one port should not directly affect the probability of treatment for other ports. While spatial correlation in outcomes is explicitly modeled, the investment decisions themselves should be independent across space, conditional on observable characteristics. This assumption allows us to identify the causal effect of investment separate from strategic investment patterns.

3.3 Stable Unit Treatment Value Assumption (SUTVA) Modification

The traditional SUTVA assumption is modified to explicitly account for spatial spillovers. Rather than assuming no interference between units, we model the spatial interaction through the weight matrix W. The spatial weights matrix W defines the relationship between ports, with $w_{ij} = 1$ if ports i and j are in the same country, and 0 otherwise. This modification allows us to decompose the total effect into direct effects and spillover effects.

3.4 Spatial Stationarity

The spatial relationship between ports is assumed to be stable over the study period. The spatial weight matrix W remains constant, implying that the geographic relationship and potential for spillovers between ports does not change substantially. This enables consistent estimation of spatial effects over time.

3.5 Error Structure

The error terms are assumed to be independent and identically distributed after accounting for spatial dependence through the model structure. Any remaining spatial correlation in errors would indicate model misspecification. We test this through Moran's I statistics on model residuals.

3.6 Identification Strategy

Causal identification relies on the combination of:

1. Temporal variation from the DID design
2. Spatial variation from the weight matrix specification
3. Selection on observables controlled through matching
4. Fixed effects controlling for time-invariant confounders

3.7 Specification

We employ two primary empirical models. The port-level DID model is specified as:

$$PLSCI_{it} = \alpha + \beta DID_{it} + \sum_{i=0}^{N} b_j X_{it1} + u_i + v_t + \varepsilon_{it} \tag{1}$$

Where $PLSCI_{it}$ represents port liner shipping connectivity index, DID_{it} is the treatment variable for Chinese investment, and X_{it} includes control variables such as container throughput, trade volume, GDP per capita, population, FDI, and political stability.

The spatial spillover model is specified as:

$$PLSCI_{it} = \alpha + (\beta + W\gamma)DID_{it} + \beta X + \rho Wx + u_i + v_t + \varepsilon_{it} \tag{2}$$

Where W represents the spatial weight matrix, and γ_3 captures spatial spillover effects. The model is estimated using maximum likelihood estimation to account for the spatial structure. Standard errors are clustered at the country level to account for potential correlation in outcomes within countries. The spillover effects are calculated through partial derivatives that account for both direct and indirect impacts of the treatment.

4 Key Findings

Our analysis reveals that Chinese investments significantly improved port connectivity with a coefficient of 3.4553 (significant at 1% level). Regional heterogeneity analysis shows varying effects across regions, with the strongest impact in Asia (5.7569), followed by Europe (4.4916), and Africa (1.5586). The impact also varies by ownership structure, with controlling stakes showing the strongest effect (5.2055), followed by minority stakes (3.6221), and no equity investments (1.5849).

Spatial spillover analysis demonstrates significant positive effects, with a total effect of 8.1086, direct effect of 3.8575, and indirect effect of 4.2512 (all significant at 1% level). At the country level, investments showed significant positive impact on national container throughput (coefficient: 1.1630, significant at 1%). This effect operates through increased tax revenue (162% increase), higher trade volume (17% increase), and expanded manufacturing exports (24% increase). The effects are particularly strong in countries with lower per capita GDP and less developed logistics systems while remaining consistent across different industrial structures.

5 Robustness Checks

The findings are supported by extensive robustness checks. Parallel trend tests confirm the validity of the DID assumptions, showing no significant differences in pre-treatment trends and gradually increasing post-treatment effects for both port and country-level analyses. Propensity score matching using trade volume, GDP per capita, and political stability as matching variables achieves a post-matching balance with standardized differences below 10%, while treatment effects remain significant. Placebo tests using 500 iterations of random treatment assignment confirm that the true effect is significantly different from the placebo distribution.

6 Heterogeneity Analysis

The analysis reveals significant heterogeneity across different dimensions. Economic development level analysis shows stronger effects in less developed countries, with a negative interaction with GDP per capita, suggesting that investment helps fill infrastructure gaps. Logistics system efficiency analysis indicates stronger effects in countries with lower logistics performance, where investment helps overcome infrastructure bottlenecks and facilitates logistics system modernization. Industrial structure analysis shows no significant heterogeneity across different industrial structures, suggesting that investment strategies are adaptable and effects are independent of the existing industrial base.

7 Policy Implications

Our findings suggest several policy recommendations. For Chinese companies, developing differentiated investment strategies based on regional characteristics and strengthening communication with host country governments is crucial. Companies should also enhance their localization capabilities to better integrate with host countries' economies. For governments, establishing comprehensive support systems for overseas port investments, providing information and risk assessment services, and strengthening international cooperation are essential steps for facilitating successful port investments.

8 Conclusions

This research provides robust empirical evidence that Chinese investments in overseas ports have significant positive effects on both port connectivity and container throughput, with substantial spillover benefits to host countries. The effects vary by region and investment structure, suggesting the importance of tailored investment strategies. The study contributes to the literature by providing a comprehensive quantitative analysis of Chinese port investments, identifying specific channels of impact, measuring spatial spillover effects, and offering evidence-based policy recommendations. These findings support the economic value of the Belt and Road Initiative's maritime component while highlighting areas for improvement in implementation.