The Impact of High-Quality Development Policies for Inland Water Transportation on Urban Industrial Economy: A Difference-in-Differences (DID) Analysis of Jining and Zaozhuang

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Abstract. Transportation infrastructure construction is a pivotal driver of regional industrial and economic development. To enhance inland waterway connectivity and stimulate economic growth, Jining City, Shandong Province, enacted policies aimed at the high-quality development of its inland waterway transportation system. To explore the promoting effect of this policy on the regional secondary industry economy, this experiment selected Zaozhuang City, which is geographically adjacent and has a similar industrial foundation, as the control group. The secondary industry added value data of the two cities over a period of 11 years (2014-2024) were reviewed, and a difference-in-differences (DID) model was constructed for empirical testing. The findings indicate that the shipping support policy exerted a statistically significant positive impact on the value-added of the secondary industry in Jining City.

Keywords: Inland Water Transportation, Difference-in-Differences (DID)Model, Secondary Industry, Policy Evaluation, Industrial Economy.

1 Introduction

Within the modern economic framework, transportation engineering plays a critical role in facilitating regional integration and growth. Among various transportation methods, inland waterway transportation has the characteristics of being environmentally friendly and having low costs. In 2021, in order to consolidate inland waterway shipping projects and promote regional economic development, the Jining Municipal People's Government issued the "Opinions on Accelerating the High-Quality Development of Jining Inland Waterway Transportation", and introduced policies such as renovating port infrastructure and building intelligent port and shipping projects. This policy once indicated that Jining was about to carry out systematic optimization of its shipping projects. To rigorously assess the economic externalities of this transportation engineering policy, this paper adopts the canonical Difference-in-Differences (DID) methodology. Designating Jining City as the treatment group and Zaozhuang City as the control

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group, the study conducts a comprehensive data analysis to isolate the policy's promotional effect on the regional secondary industry's economic performance.

2 Literature Review and Research Process

Currently, scholars globally have investigated the innovative factors and development directions of inland waterway transportation from various perspectives. From an engineering standpoint, Hasan et al. proposed a hybrid integration model to predict the inland container throughput in four countries along the Rhine River, with higher accuracy than traditional methods, providing support for waterway planning[1]. Hasan focused on domestic river oil tankers and passenger ships in Bangladesh, using 3D modeling and CFD numerical simulation to design a ship design that reduces the resistance of inland waterway transportation[2]. From a social science perspective, Al Amien based on the theory of innovation diffusion, explored the influencing factors of the adoption of autonomous inland waterway transportation[3]. Chang Jiafu analyzed the dual impacts of digital transformation on the port and shipping market and proposed four strategies[4]. Bianca Duldner-Borca et al. developed a benefit quantification model to assist in evaluating the economic benefits generated by inland waterway transportation[5]. To fill the research gap, this paper employs the DID model to assess the causal effect of the inland waterway support policies in 2021 on the secondary industry of the region. The basic econometric model set up is as follows:

$$Y_{it} = \alpha + \beta_1 Treat_i + \beta_2 Post_t + \beta_3 (Treat_i \times Post_t) + \epsilon_{it}$$

Where dependent variable Y_{it} denotes the value-added of the secondary industry in cityi in year t (unit: 10^8 Yuan). Treati is the urban number indicator, where Zaozhuang is 0 and Jining is 1; $Post_t$ is the policy implementation stage, where the value is 0 if no relevant policy is implemented and 1 if it is implemented; the explanatory variable $Treat_i \times Post_t$ is the interaction term between the treatment group dummy variable and the policy time dummy variable. ϵit represents the random disturbance term. The selection of Zaozhuang as the control group is predicated on two criteria: geographical proximity and industrial homogeneity. Both cities serve as critical nodes along the Beijing-Hangzhou Grand Canal and historically share a foundation in resource-based heavy chemical industries. Comparing the changes in the added value of the secondary industry in the two cities before and after the implementation of policies in 2021, it is possible to better reduce interference and assess the net economic gain. The data used were sourced from the 2024 statistical yearbooks of the two municipal governments， covering the periodfrom 2014 to 2024. The primary metric is "Secondary Industry Value-Added (billion Yuan)," as detailed in Table 1.

Table 1. Secondary Industry Added Value of Jining and Zaozhuang (2014–2024)

Year	Y_0 (Zaozhuang, 10^8Yuan)	Y_1 (Jining, 10^8Yuan)
2014	623.51	1530.60
2015	650.97	1632.55
2016	665.00	1672.79
2017	715.77	1794.96
2018	738.56	1833.59
2019	741.90	1745.04
2020	709.10	1707.47
2021	789.28	1997.83
2022	829.44	2026.01
2023	882.69	2112.57
2024	920.15	2176.01

3 Empirical Analysis

3.1 Parallel Trend Assumption and Descriptive Statistics

The validity of the DID estimator hinges on the "parallel trend" assumption, which posits that, absent the policy intervention, the treatment and control groups would have exhibited similar temporal trends. Specifically, if there were no such policy, the trends of the secondary industry output value in Jining and Zaozhuang should have remained consistent. When Jining implemented this policy, this parallel trend was gradually broken. The specific conditions that need to be met include at least one of the following: (1) After the policy was implemented, the growth rate difference between the secondary industry output value of Jining and Zaozhuang significantly expanded, and the growth rate of Jining was overall higher than that of Zaozhuang; (2) After the policy was implemented, the growth trend of the secondary industry output value in both cities remained approximately parallel, but the absolute gap between the secondary industry output value of Jining and Zaozhuang significantly increased, and the absolute scale of Jining continued to be higher than that of Zaozhuang.

First of all, in general, the value added of the secondary industry in Jining has been greater than that in Zaozhuang throughout these eleven years. Before 2021, the growth slopes of the secondary industry value added in both cities were basically parallel, indicating that this experiment may have met the prerequisite of the "parallel trend" of the difference-in-differences model. The descriptive statistics in the above text have laid a qualitative foundation for the establishment of the parallel test and the empirical results. Due to the uniqueness of this policy pilot, the number of control samples is limited, and the traditional panel data difference-in-differences method (DID) faces the limitation of exhausted degrees of freedom and is difficult to provide standard errors with progressive nature to complete a strict quantitative parallel trend test. Therefore, it is necessary to reprocess the original data and adopt a more direct method to test the data. Consequently, this study employs a direct comparative approach by analyzing absolute differences and growth rates (Table 2).

Table 2. Data Processing for Parallel Trend Assumption: Absolute Difference and Growth Rates

Year	Absolute Sec. Ind. Value Gap between Two Cities 10^8Yuan	Jining Sec. Ind. Value Growth %	Zaozhuang Sec. Ind. Value Growth %
2014	-907.09	——	——
2015	-981.58	6.66	4.40
2016	-1007.79	2.46	2.16
2017	-1079.19	7.30	7.63
2018	-1095.03	2.15	3.18
2019	-1003.14	-4.83	0.45
2020	-998.37	-2.15	-4.42
2021	-1208.55	17.01	11.31
2022	-1196.57	1.41	5.09
2023	-1229.88	4.27	6.42
2024	-1255.86	3.00	4.24

As evidenced in Table 2, the absolute difference in secondary industry value-added between Jining and Zaozhuang fluctuated around an average of 101.031 billion Yuan during the pre-policy period (2014–2020). Post-implementation (2021–2024), this gap exhibited a marked upward trend, rising to an average of 122.272 billion Yuan—an increase of 21.240 billion Yuan (21.02%). Although a slight contraction occurred in 2022, the gap resumed its expansion in 2023 and 2024, consistently remaining above 119.657 billion Yuan. This supports the validity of the "parallel upward shift" hypothesis. Continuing to analyze the growth rate of the secondary industry output value in the two cities, it was found that after the implementation of the policy, the growth rate of the secondary industry output value in Jining did not significantly increase even after enjoying the benefits of the policy that just took effect in 2021. The above results suggest that the main effect of this policy lies in enhancing the upper limit of the overall economic scale, resulting in a "parallel upward shift" trend of the secondary industry output value. Additionally, a canal reform system implemented throughout the province in 2023 simultaneously covered Jining and Zaozhuang. This might have caused Zaozhuang's growth rate to suddenly surge and exceed that of Jining. This discussion will be presented in section 4.

3.2 DID Regression Results and Placebo Test

As presented in Table 3, the regression analysis yields a coefficient of the interaction term $Treat_i \times Post_t$ that is positive and statistically significant at the 5% level ($p=0.006$). The high R^2 value (0.983) underscores the model's robust explanatory power regarding actual economic trends.

Table 3. Empirical Results of the Difference-in-Differences (DID) Model

Results	B	Std. Error	Beta	t	p
Coefficient	692.116	28.926		23.927	0
$Treat_i$	1010.313	40.908	0.893	24.697	0
$Post_t$	163.274	47.968	0.139	3.404	0.003
$Treat_i \times Post_t$	212.402	67.837	0.145	3.131	0.006
R^2	0.983				

To verify that the observed effects are not driven by unobserved time trends or omitted variables, a placebo test was conducted using a falsified policy timing. Setting 2018 (a stable period) as the false policy implementation time point, redefine the policy time dummy variable Postf (0 before 2018 and 1 after 2018), and construct the false policy interaction term $Treat_i \times Post_f$..The regression results show that the significance p-value is 0.198,failing to reach statistical significance at the 5% level. This confirms that the policy effect is not caused by random time trends, unobserved omitted variables, or other non-policy factors.

4 Discussion: Mechanisms of Action

The promotion effect of inland waterway shipping policies on the secondary industry lies in the combination of agglomeration effects. And cost optimization. Firstly, the optimization of logistics engineering would directly reduce the direct costs of enterprises' production and operation. Industrial raw materials often have the characteristics of large quantity and low value. To reduce the enterprise's logistics costs, the shipping policy of Jining City in 2021 clearly proposed to develop canal logistics and improve the quality of services. While optimizing the inland waterway shipping projects, it encouraged various industrial enterprises to cooperate with shipping enterprises. Currently, many enterprises have increased their demand for raw materials under the support of this policy, which significantly promoted the economic development of Jining industry. Secondly, improved transportation infrastructure enhanced industrial agglomeration. The increased capacity of shipping channels allowed Jining to accommodate larger-tonnage vessels, attracting a large number of manufacturing enterprises to cluster around the port, thereby forming economies of scale and scope， further amplifying the secondary industry's value-added.

5 Reflection and Limitation

This study acknowledges certain limitations. Firstly, due to the uniqueness of the policy and the region, this study only selected Zaozhuang City, which is geographically and industrially similar, as a single control group (N=2). This has restricted the classic large-sample parallel trend test. Secondly, the strict exogeneity requirement of the DID model that the control group remains unaffected by similar policies during the observation period is rather difficult to achieve. Notably, the 2023 "Three-Year Action Plan for Accelerating the High-Quality Development of Inland Waterway Shipping in Shandong Province (2023-2025)" covered the entire Shandong province. This phenomenon might cause the research to underestimate the policy effect and explain why the growth rate of the secondary industry in Zaozhuang City even slightly exceeded that of Jining City during the period of 2023-2024.

6 Conclusions

This paper constructed a difference-in-differences (DID) model utilizing official economic data from 2014 to 2024 to evaluate the efficacy of Jining City's 2021 inland river shipping support policies. The empirical evidence confirms that the transportation engineering policy successfully stimulated the secondary industry. Based on these findings, this paper proposes the following recommendations: Firstly, efforts should be continued to strengthen the infrastructure construction of inland river shipping. Relevant departments should continue to increase investment in the widening of waterways, thereby improving the overall operational efficiency of the transportation system. Secondly, related industrial clusters should be constructed. Port transportation must closely integrate the shipping planning with the layout of the port-adjacent industrial parks to achieve better development.

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