

SPATIAL ECONOMETRIC ANALYSIS OF PORT THROUGHPUT ON THE QUALITY OF ECONOMIC EXTERNAL CIRCULATION DEVELOPMENT IN HEBEI PROVINCE

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ABSTRACT. *The 20th National Congress report pointed out the need to accelerate the construction of a new development pattern of dual circulation, in which the focus of external circulation should be on improving quality and level. As an important hub for international circulation, ports have a significant impact on the quality of external economic development. And it is generally accepted in the academic community that this impact is related to the spatial distance between economic regions and ports. Therefore, this article analyzes the impact of the throughput of ports in Hebei Province from 2010 to 2020 on the quality of external circulation development through the construction of an economic quality index system and a spatial econometric model. The study shows that the cargo throughput of ports in Hebei Province can promote the quality of external circulation development, and the quality of external circulation development between cities in Hebei Province mutually affects each other.*

Keywords: Port throughput, Economic external circulation, Spatial measurement

1. Introduction. The 20th National Congress report pointed out that, when promoting the new development pattern of dual circulation, more attention should be paid to the quality and level of external circulation [1]. As an important hub connecting domestic and foreign markets and a direct window for opening up to the outside world, ports have an important impact on the quality of economic external circulation development. The port throughput is an important indicator to measure the comprehensive strength of the port. Based on this, this article studies the influence relationship between port throughput and the quality of economic external circulation development to determine the role of ports in improving the quality of economic external circulation development and provide a theoretical basis for its improvement.

2. Literature Review. According to the research results of scholars in the field of port logistics, the research status of this paper can be divided into the research of port logistics on urban economic growth and the research of the influence of port logistics on foreign investment and foreign trade.

2.1. A study of port logistics on urban economic growth. Scholars have conducted ample empirical research on the impact of port logistics on urban economic growth. Chang et al. [2] studied the impact of South African ports on the economy using input-output analysis. Özer et al. [3] confirmed that maritime container transportation in Turkey has made a significant contribution to economic growth. Cheng [4] argued that the economies

of scale and specialized division of labor formed by the agglomeration of port-side industries lead to lower costs, higher productivity, and concentration of talent, resulting in sustained regional economic growth. Zhang [5] applied a Vector Autoregressive Model (VAR) and found that the growth rate of port throughput has a positive impact on the growth rate of Gross Domestic Product (GDP) per capita.

Studies on the application of spatial econometric models in the field of port logistics include: Marinos et al. [6], Wu et al. [7] and Diao et al. [8] all applied spatial econometric models to confirm that ports can have spillover effect on urban economic growth.

2.2. Research on the impact of port logistics on foreign investment and foreign trade. Promoting international circulation requires attracting high-quality foreign investment and actively developing foreign trade [9]. According to studies confirming the influence of port logistics on both foreign investment and foreign trade. Yang [10] proved that the development of the port logistics level can promote the growth of goods import and export trade. Chen [11] proved that the improvement of port facility convenience can significantly improve export trade. The development of port logistics can attract international economic and trade enterprises and absorb large amounts of foreign investment [12]. Liang et al. [13] found that the increase in the level of port infrastructure development is conducive to boosting the trade import and export volumes of the member countries.

According to the above discussion, it can be seen that port logistics may affect the quality of development of the external economic cycle through the impact on foreign investment and foreign trade, but there is a lack of research on port logistics and the quality of urban economic external circulation development, and the existing literature mainly focuses on the influence of port logistics on urban economic growth. In addition, the mechanism by which port logistics affect the quality of urban economic external circulation development is not clear, especially since the spatial interaction mechanism has not been studied. Therefore, this study takes Hebei Province as an example, considers the spatial factors between ports and cities, and studies the impact of port throughput on the quality of urban economic external circulation development.

3. Data Sources, Variable Selection and Model Setting.

3.1. Data sources. This article selects data from the ports and cities in Hebei Province from 2010 to 2020, sourced from the “Hebei Statistical Yearbook” and the “Port Statistical Yearbook” from 2011 to 2021, the 2010-2020 statistical reports from the Shijiazhuang Customs, and annual statistical reports from various cities.

3.2. Variable selection.

1) Explanatory variables. Port cargo throughput and container throughput. Port cargo throughput and container throughput can reflect the scale and production capacity of the port [14].

2) Explained variable. Quality of economic external circular development. It is a comprehensive index that reflects the quality level of economic circulation development in cities in Hebei Province. It requires the construction of a multi-indicator system for comprehensive evaluation. In this paper, based on the research of Diao et al. [8] and Zeng [15] in constructing the index system of economic openness, we established the index system of the quality of economic outward circulation development in Hebei Province. The specific indicators are explained in Table 1.

In this article, the entropy method was used to process the index system of quality of economic external circulation development constructed above. The weight of the indicators is shown in Table 1, and the comprehensive score results are shown in Table 2.

TABLE 1. System of indicators for the development quality of the economic external circulation

| Tier 1 indicators | Secondary indicators | Tertiary indicators | Description | Unit | Weights |
|--|--------------------------------|-------------------------------|--|-------------|---------|
| Quality of economic external circulation | External circulation basis | Economic scale | GDP per capita | Yuan/person | 0.1519 |
| | | Industrial base | Total industrial output value above the scale | Billion | 0.2963 |
| | Degree of external circulation | Foreign trade dependence | Total imports and exports/GDP | Billion | 0.1881 |
| | | Foreign investment dependence | Actual utilization of foreign direct investment/GDP | Billion | 0.1284 |
| | | Financial deepening ratio | Deposit and loan balance of financial institutions/GDP | Billion | 0.2353 |

TABLE 2. Results of the evaluation of the quality of economic external circulation development

| Score | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Shijiazhuang | 0.421 | 0.481 | 0.462 | 0.493 | 0.508 | 0.510 | 0.532 | 0.535 | 0.557 | 0.606 | 0.630 |
| Chengde | 0.097 | 0.083 | 0.110 | 0.103 | 0.133 | 0.134 | 0.141 | 0.114 | 0.247 | 0.244 | 0.274 |
| Zhangjiakou | 0.090 | 0.100 | 0.109 | 0.118 | 0.123 | 0.125 | 0.139 | 0.192 | 0.313 | 0.315 | 0.341 |
| Qinhuangdao | 0.428 | 0.456 | 0.402 | 0.365 | 0.403 | 0.400 | 0.379 | 0.442 | 0.510 | 0.523 | 0.558 |
| Tangshan | 0.411 | 0.521 | 0.492 | 0.551 | 0.580 | 0.525 | 0.551 | 0.529 | 0.601 | 0.622 | 0.698 |
| Langfang | 0.329 | 0.340 | 0.301 | 0.334 | 0.321 | 0.317 | 0.340 | 0.318 | 0.470 | 0.448 | 0.458 |
| Baoding | 0.246 | 0.278 | 0.240 | 0.258 | 0.241 | 0.236 | 0.243 | 0.246 | 0.306 | 0.335 | 0.331 |
| Cangzhou | 0.138 | 0.172 | 0.200 | 0.229 | 0.251 | 0.244 | 0.255 | 0.258 | 0.331 | 0.350 | 0.374 |
| Hengshui | 0.171 | 0.225 | 0.224 | 0.255 | 0.249 | 0.203 | 0.201 | 0.208 | 0.339 | 0.352 | 0.366 |
| Xingtai | 0.159 | 0.195 | 0.156 | 0.178 | 0.189 | 0.159 | 0.185 | 0.186 | 0.314 | 0.324 | 0.356 |
| Handan | 0.231 | 0.267 | 0.276 | 0.266 | 0.272 | 0.261 | 0.274 | 0.272 | 0.347 | 0.390 | 0.447 |

3) Control variables. Based on Diao et al. [8] empirical study of the factors influencing economic openness, four factors, including industrial structure, human capital, government support, and fixed asset investment, were selected as control variables for this paper.

3.3. **Model setting.** LeSage and Pace [16] suggested constructing a spatial Durbin model and then determining the final model through testing. Therefore, this study sets the spatial Durbin model as follows [17]:

$$Eecq_{it} = \rho \sum_{i=1}^n W_{ij} Eecq_{jt} + \delta TP_{it} + \gamma \sum_{j=1}^n W_{ij} TP_{jt} + \omega x_{it} + \sigma \sum_{j=1}^n W_{ij} x_{jt} + \varepsilon_{it} \quad (1)$$

In the formula, $Eecq_{it}$ represents the dependent variable, TP_{it} represents the independent variable, W_{ij} represents the spatial weight matrix, $\sum_{i=1}^n W_{ij} Eecq_{jt}$ and $\sum_{j=1}^n W_{ij} TP_{jt}$ represent the spatial lag of the dependent and independent variables, x_{it} represents control variables including industrial structure (WS), human capital (HC), government support (GS), and fixed asset investment (IN), $\sum_{j=1}^n W_{ij} x_{jt}$ represents the spatial lag of control variables, ρ represents the spatial autocorrelation coefficient, δ represents the coefficient of the independent variable, γ represents the coefficient of the spatial lag of the independent

variable, ω represents the control variable coefficient, σ represents the coefficient of the spatial lag term of the control variable and ε_{it} represents the random error term.

4. Empirical Results and Analysis.

4.1. Spatial correlation test. In the method of spatial correlation test, this article chooses the global Moran's I index to test whether there is the spatial correlation in the quality of economic external circulation development in Hebei Province. The results are shown in Table 3.

TABLE 3. Moran's I index of the quality of economic external circulation in Hebei Province

| Year | Quality of economic external circulation | |
|------|--|---------|
| 2010 | 0.127* | (0.087) |
| 2011 | 0.169* | (0.056) |
| 2012 | 0.132* | (0.081) |
| 2013 | 0.135* | (0.079) |
| 2014 | 0.176** | (0.034) |
| 2015 | 0.147** | (0.061) |
| 2016 | 0.189*** | (0.011) |
| 2017 | 0.195*** | (0.007) |
| 2018 | 0.227*** | (0.004) |
| 2019 | 0.248*** | (0.000) |
| 2020 | 0.277*** | (0.000) |

Note: () *P*-values of test statistics in parentheses, ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively, as below.

As can be seen from the results, the Moran's I index of the quality of external economic development in Hebei Province from 2010 to 2020 is within the range of $[-1, 1]$, and passes the significance level test, indicating that there is the spatial correlation in the quality of external economic development in Hebei Province.

4.2. Model testing and analysis of empirical results.

1) Model testing

TABLE 4. LM and RLM test results

| Test variables | OLS estimation | Spatial fixed effects | Time fixed effects | Double fixed effects in space and time |
|----------------------------|----------------|-----------------------|--------------------|--|
| LM-lag | 4.349** | 296.037*** | 9.649*** | 7.226*** |
| | (0.037) | (0.000) | (0.002) | (0.007) |
| RLM-lag | 2.769** | 58.497*** | 1.247 | 15.371*** |
| | (0.096) | (0.000) | (0.264) | (0.000) |
| LM-error | 2.689* | 244.074*** | 8.484*** | 5.175*** |
| | (0.101) | (0.000) | (0.004) | (0.023) |
| RLM-error | 1.110 | 6.534*** | 0.081 | 13.320*** |
| | (0.292) | (0.011) | (0.776) | (0.000) |
| LR (SDM VS SAR) | 17.650*** | | | (0.000) |
| LR (SDM VS SEM) | 22.015*** | | | (0.000) |
| Hausman | 62.318*** | | | (0.000) |
| LR (Spatial fixed effects) | 369.221*** | | | (0.000) |
| LR (Time fixed effects) | 236.971*** | | | (0.000) |

According to the LM test and the robust LM test results, firstly, the spatial lag model and the spatial error model under spatial fixed effects and spatial-temporal double fixed effects have passed the significance level test, and the spatial Durbin model cannot be simplified to the spatial lag model and the spatial error model. Secondly, the Hausman test results show that fixed effects should be selected between random effects and fixed effects. Finally, the LR test of spatial and temporal fixed effects shows that the model should include spatial-temporal double fixed effects.

It has been verified that the spatial Durbin model set above is appropriate. Therefore, this article uses the spatial Durbin model under spatial-temporal double fixed effects for empirical analysis.

2) Analysis of the empirical results. Direct estimation of the spatial Durbin model will result in estimation bias for some parameters. This study refers to the maximum likelihood function proposed by Lee and Yu [18] to obtain parameter estimates directly, and then corrects the parameter estimation results through transformation methods. The results of direct estimation and bias correction of the spatial Durbin model are shown in Table 5.

TABLE 5. Estimation of SDM model with both spatial and temporal fixed effects

| Statistical quantities | Spatial and temporal double fixed effects | | Spatial and temporal double fixed effects (Bias correction) | |
|------------------------|---|----------|---|----------|
| R^2 | 0.9867 | | 0.9878 | |
| σ^2 | 0.0003 | | 0.0003 | |
| $Log-L$ | 322.8326 | | 322.8326 | |
| CT | 0.0001** | (0.0149) | 0.0001** | (0.0131) |
| CV | -0.0002 | (0.1316) | -0.0002 | (0.1329) |
| WS | -0.0276* | (0.0693) | -0.0285** | (0.0348) |
| HC | -0.0809 | (0.5560) | -0.0839 | (0.4916) |
| GS | 0.4249*** | (0.0027) | 0.4355*** | (0.0005) |
| IN | -0.0857*** | (0.0004) | -0.0833*** | (0.0001) |
| W^*Eecq | -0.6685*** | (0.0026) | -0.9989*** | (0.0000) |
| W^*CT | -0.00003*** | (0.0000) | -0.00002*** | (0.0000) |
| W^*CV | 0.0029*** | (0.0001) | 0.0027*** | (0.0000) |

According to the estimation results, it can be seen that there is a negative spillover effect of the quality of economic external circulation development ($Eecq$), that is, the improvement of the quality of economic external circulation development in cities in Hebei Province will inhibit the quality of economic external circulation development in neighboring provinces. The reason may be that when the quality of economic external circulation in cities is high, it will attract the inflow of resource elements from neighboring provinces, thereby exerting an inhibitory effect on neighboring provinces.

The cargo throughput of ports (CT) significantly promotes the quality of economic external circulation development in port cities in Hebei Province, but it has an inhibitory effect on the quality of economic external circulation development in neighboring non-port cities, whose effect is not significant. This may be because the effect weakens as the geographic range expands. The container throughput (CV) has no significant impact on the quality of economic external circulation development in port cities in Hebei Province, but it has a significant positive promoting effect on the quality of economic external circulation development in non-port cities.

Human capital (HC) has no significant impact on the quality of economic external circulation development in Hebei Province. Fixed asset investment (IN) and industrial

structure (WS) both significantly inhibit the quality of economic external circulation development in Hebei Province. This may be because the infrastructure construction level of port cities currently cannot meet the level of logistics demand, or the industrial layout is unreasonable, which cannot optimize resource allocation. Government support (GS) significantly promotes the quality of economic external circulation development in Hebei Province.

4.3. Robustness test. The robustness test is to verify the reliability of the above conclusions, this paper uses the method of replacing spatial weights for the robustness test, and the results are shown in Table 6.

TABLE 6. Robustness test results

| Statistical quantities | Spatial and temporal double fixed effects | Spatial and temporal double fixed effects (Bias correction) |
|------------------------|---|---|
| R^2 | 0.9837 | 0.9845 |
| σ^2 | 0.0004 | 0.0003 |
| CT | 0.0005*** | (0.0000) |
| CV | -0.0005*** | (0.0011) |
| WS | 0.0006 | (0.9766) |
| HC | -0.1381 | (0.1364) |
| GS | 0.2081 | (0.1364) |
| IN | -0.0768*** | (0.0020) |
| W^*Eecq | -0.1336 | (0.1915) |
| W^*CT | -0.00001*** | (0.0001) |
| W^*CV | 0.0007*** | (0.0039) |

According to the results of the robustness test, it can be seen that the significance of the impact of port throughput on the quality of economic external circulation development in Hebei Province in Table 6 remains consistent with that in Table 5, thus proving that the conclusions obtained in this paper are robust and reliable.

5. Conclusions and Recommendations. This article draws the following conclusions. First, there is a spatial correlation in the quality of external economic external circulation development in Hebei Province. Second, there is a significant negative spillover effect on the quality of urban external economic circulation development in Hebei Province. Third, the significant increase in port cargo throughput in Hebei Province has promoted the quality of external economic circulation development.

Based on the research conclusions, this article proposes the following suggestions. First, continue to promote the coordinated development of Beijing-Tianjin-Hebei. Coordinated development can help to reduce the inhibitory effect of surrounding areas on the quality of external economic circulation development in Hebei Province. Second, strengthen policy support. Formulate and implement policies and measures that are conducive to the development of the circular economy. As estimated in the results, government support has the greatest promoting effect on the quality of external economic circulation development in Hebei Province. Third, increase investment in infrastructure construction. Ports are important nodes for domestic and international circulation, while infrastructure construction is the guarantee for port logistics and intermodal transportation. Therefore, it is necessary to continue to increase investment in port-city infrastructure and optimize and upgrade port infrastructure.

In future research, in addition to the port throughput factor, other factors of the port, such as the number of berths in the port and the length of the quay, will also be considered to comprehensively analyze the impact of port logistics on the quality of economic external circulation development.

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REFERENCES

- [1] J. Xi, The implementation of the new development concept in the new development stage necessarily requires the construction of a new development pattern, *Qiushi*, no.17, pp.4-17, 2022.
- [2] Y. T. Chang, S. H. Shin and P. T. W. Lee, Economic impact of port sectors on South African economy: An input-output analysis, *Transport Policy*, vol.35, pp.333-340, 2014.
- [3] M. Özer, Ş. Canbay and M. Kirca, The impact of container transport on economic growth in Turkey: An ARDL bounds testing approach, *Research in Transportation Economics*, vol.88, 101002, 2021.
- [4] G. Cheng, *The Relationship between Industrial Cluster of the Port Logistics and Regional Economy*, Master Thesis, Dalian Maritime University, 2014.
- [5] M. Zhang, Research on the relationship between port prosperity and regional economic development – An empirical analysis based on panel vector autoregressive model, *The World of Survey and Research*, no.9, pp.58-64, 2021.
- [6] T. Marinos, A. Belegri-Roboli, P. G. Michaelides and K. N. Konstantakis, The spatial spillover effect of transport infrastructures in the Greek economy (2000-2013): A panel data analysis, *Research in Transportation Economics*, vol.94, 101179, 2022.
- [7] Z. Wu, S. H. Woo, P. L. Lai and X. Chen, The economic impact of inland ports on regional development: Evidence from the Yangtze River region, *Transport Policy*, vol.127, pp.80-91, 2022.
- [8] S. Diao, H. Kuang, Z. Li and J. Li, The spatial spillover effect of port development on economic openness: Research based on two-regime spatial durbin model, *Management Review*, vol.33, no.1, pp.54-67, 2021.
- [9] Z. Dong and C. Li, China's double-circulation new development pattern: Source, implications and policy orientation, *Journal of the CCPS (CAG)*, vol.24, no.5, pp.47-55, 2020.
- [10] L. Yang, Influence of port logistics of maritime silk road on international trade – Based on panel data of 15 ports, *Journal of Taiyuan University (Social Science Edition)*, vol.18, no.3, pp.14-17+26, 2017.
- [11] J. Chen, *Analysis of the Impact of Port Convenience on China's Export Trade under the Background of "One Belt and One Road"*, Master Thesis, Jinan University, 2018.
- [12] L. Xu, *International Comparison on Economic Spurring Effect of Port Logistics*, Master Thesis, Zhejiang University, 2013.
- [13] K. Liang, J. Liang and T. Dai, Study on the economic impact of port connectivity infrastructure development on RCEP member countries, *Marine Technology*, no.2, pp.68-72, 2022.
- [14] Q. Shen, Z. Han and J. Guo, Research on the relationship between port logistics and urban economic growth: A case study of Dalian, *Geography and Geo-Information Science*, vol.29, no.1, pp.69-73, 2013.
- [15] T. Zeng, The economic openness measurement and analysis of the Guangdong-Hong Kong-Macao Greater Bay area and its influencing factors, *Special Zone Economy*, no.5, pp.44-46, 2021.
- [16] J. P. LeSage and R. K. Pace, *Introduction to Spatial Econometrics*, CRC Press, 2009.
- [17] H. Wang, Z. Wang and L. Zhao, Difference analysis of the impact of port adjacency on the high-quality development of urban economy in Hebei Province, *ICIC Express Letters, Part B: Applications*, vol.14, no.1, pp.81-88, 2023.
- [18] L. F. Lee and J. Yu, Estimation of spatial autoregressive panel data models with fixed effects, *Journal of Econometrics*, vol.154, no.2, pp.165-185, 2010.