RESEARCH ARTICLE

Enhancing Sustainable Development through Industry Output Analysis: A Case Study of Xiamen Port

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Abstract: Examining industry output, productive berths, and GDP in China informs effective policy strategies for sustainable development, with a focus on key ports like Xiamen Port in the southeast region of china. Utilizing multiple regression analysis, this study explores the relationships among industry output, productive berths, and GDP, particularly focusing on Xiamen Port's significance in China's economic landscape. A negative correlation exists between primary industry output and GDP, emphasizing the need for sustainable industrial policies. Secondary industry also influences GDP negatively, albeit to a lesser extent. Increased productive berths positively impact GDP, highlighting infrastructure's role in economic growth. Balancing economic growth with sustainability requires targeted policies. Infrastructure development is crucial for economic performance. However, cautious interpretation is essential due to regression analysis limitations.

Keywords: Multiple regression analysis, Industry output, Productive berths, Xiamen Port

Citation: Xinyu Lin, Chen-Yuan Chiu, Yichia Lin, 2024. Enhancing Sustainable Development through Industry Output Analysis: A Case Study of Xiamen Port. Journal of Sustainable Urbanization, Planning and Progress, 8(1): 1-4. http://doi.org/10.26789/JSUPP.2024.01.001

1 Introduction

By Port competitiveness stands as a pivotal subject within the realm of port development, garnering extensive scholarly scrutiny. This review delves into and synthesizes six pertinent articles published within the last five years, focusing on the salient factors influencing port competitiveness, methodologies for assessment, and their consequential impact on economic development. To begin, Alamoush, Ballini,and Dalaklis [1], Cull inane and Song [2] undertook a comprehensive investigation into port selection and competitive dynamics within global supply chains. Their findings revealed a myriad of determinants influencing port selection, encompassing geographical considerations, service quality, and operational expenditures. Such insights offer valuable guidance for port authorities in crafting strategies aimed at augmenting port competitiveness.

Subsequently, Ducruet and Lee [3] provided an overarching exposition on the status quo and future trajectories of research within the domain of maritime transport geography. Their discourse accentuated the pivotal role played by geographical factors in shaping maritime transport dynamics, proffering a roadmap for future research endeavors aimed at guiding port management practices and steering the course of maritime industry development. Furthermore, Gonzalez-Feliu and Morana [4] conducted a comprehensive review of existing frameworks pertaining to sustainability indicators in port competitiveness assessment. Their analysis underscored the pivotal role played by sustainability metrics in evaluating port competitiveness, advocating for their integration into strategic planning initiatives aimed at fostering sustainable port development and bolstering competitiveness. Additionally, Lee, Ducruet, and Ng [5] embarked on a rigorous examination of the evolutionary trajectory of port hierarchy and network structure within the Asian context. Their findings delineated the distinctive features and developmental trajectories characterizing the Asian port landscape, furnishing invaluable insights to inform future port development strategies and optimize port network configurations. Concluding the discourse, Notteboom and Pallis [6], Quintano, Mazzocchi, and Rocca. [7] deliberated on the ramifications of port regionalization on port development endeavors. Their analysis shed light on the emergent challenges and opportunities precipitated by the trend of port regionalization, necessitating calibrated responses from port management authorities and policymakers to navigate the evolving landscape effectively. Summary, the corpus of recent scholarship contributes significantly to our comprehension and enhancement of port competitiveness. Future research endeavors may delve deeper into methodologies for port competitiveness assessment, strategic imperatives for port development, and the intricate nexus between ports and economic development, thereby furnishing nuanced insights to guide port management practices and policy formulation endeavors.

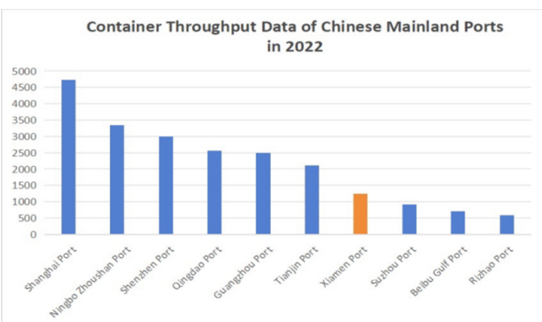

Figure 1 China's Top Ten Container Ports

2 Data

Influencing factors collected include GDP, Cargo Throughput, Foreign Trade Volume, output value of the Primary industry, output value of the Secondary industry, and the number of Productive Berths. Relevant data and corresponding time periods are presented in Table 1. From the data, it appears that the GDP of Xiamen Port has not been significantly affected by the COVID-19 pandemic.The reason for selecting Xiamen Port is that it is one of the top ten container ports with a throughput as shown in Figure 1.

Table 1 The relevant influencing factors of Xiamen Port source: Xiamen Port Authority

Year	GDP	Cargo Throughput	Foreign Trade Volume	Primary Industry output	Secondary Industry output	Productive Berths
2014	3443.26	20503.96	5132.49	46.12	1563.40	152
2015	3806.94	21023.31	5187.70	46.65	1688.76	159
2016	4118.13	20910.78	5091.55	46.15	1783.47	164
2017	4607.83	21116.25	5816.04	45.54	1987.87	165
2018	5468.61	21719.93	6005.31	47.24	2264.41	165
2019	6015.04	21343.91	6412.89	57.40	2493.99	175
2020	6435.02	20749.54	6915.77	61.03	2519.84	176
2021	7295.67	22755.99	8876.52	62.01	2882.89	182
2022	7802.66	21939.62	9225.59	62.19	3233.56	184
2023	8066.49	22020.34	9400.10	59.35	2867.94	188

2.2 Method

Multiple regression is suitable for analyzing the impact of multiple independent variables on the dependent variable, enhancing the comprehensiveness of the model and enabling a more accurate understanding of the relationships among influencing factors. Multiple regression analysis in the domain of port operations aids port managers in gaining a deeper understanding of the interrelations among diverse factors. This comprehension empowers them to devise more efficacious management strategies, consequently elevating the operational efficiency and competitiveness of ports. Therefore, a multiple regression equation is provided as Equation 1.

Regression analysis allows for the inclusion of multiple explanatory variables to explain changes in the dependent variable. This is particularly useful when there are several factors influencing the outcome, such as various operational factors affecting port performance. Regression analysis offers flexibility in modeling different types of relationships between variables, such as linear, nonlinear, or interaction effects. Hence, the decision not to utilize time series research methods.

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\epsilon \quad (1)$$

Where:

Y is the dependent variable (GDP).

X_1,X_2,X_3,X_4,X_5 are the independent variables (X_1 Cargo Throughput, X_2 Foreign Trade Volume, X_3 Primary Industry output, X_4 Secondary Industry output, X_5 Productive Berths)

$\beta_0,\beta_1,\beta_2,\beta_3,\beta_4,\beta_5$ are the regression coefficients.

ϵ is the error term.

3 Data analysis

Following software repeated calculation, the regression outcomes corresponding to the aforementioned dataset are presented in Table 2. With an R-squared value of 0.97 after adjustment, the model meets the standard criteria for multiple regression analysis.

Table 2 Regress analysis

	Cargo throughput	Foreign trade volume	Primary industry	Secondary industry	Productive berths
SD	0.26	0.19	35.7	1.29	29.6
Coef	-0.09	0.22	-3.58	1.21	58.30
P-value	0.921	0.711	0.349	0.416	0.013
GDP Coef	0.952	0/973	0.565	0.989	0.956
R-squared	0.97	DF=5			

$$YGDP=-3376.28-0.0134X_1+0.1684X_2-3.7534X_3+1.4569X_4+56.0361X_5 \quad (2)$$

Where X represents the dependent variable, and X_1, X_2, X_3, X_4, and X_5.

The data in Tab2 reveals a significant GDP level, with X_5 indicating a certain relationship between berth and GDP volume. Due to the limited number of values, conducting further analysis such as PCA or dimensionality reduction on the regression equation (2) is not recommend. Another observation is the correlation coefficient of each factor with GDP. X_3 demonstrates a lower correlation. Removal of the X_3 factor could be a possibility. In addition, linear regression analysis was performed on the primary industry and the secondary industry using GDP to obtain equations 3 and 4.

$$GDP=2472.315-352.948\times \text{Primary Industry output} \quad (3)$$

$$GDP=9645.56-33.811\times \text{Secondary Industry output} \quad (4)$$

$$GDP\approx-2796.455+197.220\times \text{Productive Berths} \quad (5)$$

Since Berths play an extremely important role in the port's transportation capacity, a simple regression analysis of berths and GDP yields Equation 5. After regression analysis, the slop value is 197.220. Since the harbor Berth cannot be zero, the slope analysis is not performed.

4 Finding

4.1 Industry output

A negative relationship in the context of GDP and industry output means that as one variable increases, the other variable decreases. Specifically, if there's a negative relationship between GDP and industry output, it implies that as the output of the industry increases, the GDP decreases, and vice versa. The coefficient for Primary Industry output (-352.948) suggests that for every unit increase in Primary Industry output, GDP is expected to decrease by approximately 352.948 units. This indicates a relatively strong negative relationship between Primary Industry output and GDP. In contrast, the coefficient for Secondary Industry output (-33.811) implies that for every unit increase in Secondary Industry output, GDP is expected to decrease by approximately 33.811 units. This indicates a weaker negative relationship between Secondary Industry output and GDP. Although the secondary industry is small in volume, its output value is large. It is impossible to estimate the relationship between throughput without more information.

4.2 Productive Berths

Slope indicates that with each additional unit increase in Productive Berths., GDP is expected to increase by 197.220 units. This informs us about how each unit change in Productive Berths. It shows that the regression model has a high degree of fit to the data. Productive Berths has a significant impact on changes in GDP based on the R value of a single regression as 0.984. Finding suitable land near the port for expanding productive berths may be limited, especially in rapidly urbanizing areas. Expanding productive berths requires significant investment and funding, including land acquisition, construction, and equipment upgrades, which may face financial constraints and pressures. Constructing new berths may have adverse effects on the local ecological environment, including water pollution and habitat destruction, necessitating environmental impact assessments and conservation measures. Despite the positive correlation between berths and GDP, the endeavor of increasing berths presents notable challenges.

5 Conclusion

5.1 Industry policy

The negative correlation observed in the primary industry highlights a critical policy consideration within the industrial export realm. Given the predominant reliance of the primary sector on raw material extraction, which often leads to environmental degradation, policymakers could strategically leverage this correlation in crafting export policies. By integrating this insight, policymakers can develop export strategies aimed at addressing environmental concerns and mitigating associated damages. This approach not only fosters sustainable industrial practices but also advances broader environmental conservation objectives, aligning with the imperative of promoting environmentally responsible economic development.

5.2 Productive Berths policy

The increase of berths is not an easy task. It involves complex factors such as port construction and port transportation lines. By inputting different values for Productive Berths, policymakers can predict the corresponding impacts on GDP, facilitating proactive planning and resource allocation. Understanding the relationship between GDP and Productive Berths can aid policymakers identify and mitigate potential risks. Policy makers can utilize the regression equation to proactively monitor risk management measures. For instance, if there is an expected decrease in Productive Berths due to potential factors like labour strikes or supply chain disruptions, policymakers can pre-emptively devise contingency plans. These plans would aim to alleviate any adverse impacts on GDP by implementing strategies to mitigate the effects of the anticipated reduction in Productive Berths. This proactive approach enables policymakers to effectively manage risks and safeguard economic stability in the face of potential disruptions.

Lastly, the limitation of the model lies in the uncertainty of the future. Although the model can predict changes in GDP based on the current number of Productive Berths and second industry, future events and developments may lead to inaccuracies in the model's predictions. Therefore, policymakers should exercise caution when using the model's forecast results and consider its limitations.

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