INTERNATIONAL JOURNAL OF
COASTAL, OFFSHORE & ENVIRONMENTAL ENGINEERING IJCOE Vol.11/No. 4/Autumn 2026 (1-14)

Available online at: www. Ijcoe.org

The Role of Dry Ports in Regional Economic Development: A Case Study of Yazd Dry Port

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ARTICLE INFO

Article History:
Received: 8 July
Accepted: 5 Oct
Available online ….

Keywords:
Dry Ports;
Economic Development;
Intermodal Transport;
Inland Terminal;
Yazd Dry Port

ABSTRACT

Dry ports function as strategic intermodal terminals connecting inland and maritime networks via road and rail, playing an increasingly vital role in facilitating international trade and regional economic development. Given Iran's strategic geographic position at the crossroads of major trade corridors, the development of dry ports presents a significant opportunity to enhance freight transport efficiency and stimulate regional economic growth. This study aims to evaluate the impact of the infrastructure indicators of Yazd Dry Port on regional economic development.

A mixed-methods approach was employed, combining a comprehensive literature review, expert panel evaluation, and a survey of 96 experts and specialists in maritime transport, logistics, and economic planning. Data were analyzed using descriptive and inferential statistical methods, including factor analysis (KMO = 0.77; Bartlett's test: $\chi^2 = 686.36$, $p < 0.001$), one-sample t-tests, and the Friedman test for ranking variables. The reliability of the questionnaire was confirmed with a Cronbach's alpha of 0.89.

The findings revealed that all 11 identified infrastructure indicators have a positive and significant impact on regional economic development ($p < 0.001$). The Friedman test results ranked security (mean rank = 7.04) as the most critical factor, followed by accessibility (mean rank = 6.59) and economic and financial factors (mean rank = 6.42), while transit capacity (mean rank = 5.24) ranked lowest.

This study contributes empirical evidence on the economic impacts of dry ports in the Iranian context, addressing a gap identified in previous international research. The findings provide actionable insights for policymakers, transport planners, and infrastructure developers, particularly regarding investment prioritization in security, accessibility, and economic infrastructure. The results also underscore the importance of a clear executive framework and public-private partnerships to overcome government support limitations and accelerate dry port implementation in Iran.

1. Introduction

The dynamic transformations in the global business environment over recent decades have led to a significant increase in exports and imports across various regions worldwide. According to the World Trade Organization [1], world merchandise trade volume declined by 1.2% in 2023, driven largely by high energy prices and inflation that weighed on demand for manufactured goods, particularly in Europe. In value terms, merchandise exports fell by 5% to US$24.01 trillion in 2023. However, a gradual recovery is underway, with WTO economists projecting merchandise trade volume growth of 2.6% in 2024 and 3.3% in 2025 (. The Asia-Pacific region, in particular, has demonstrated remarkable resilience, with the region's share of global nominal exports and imports rising slightly to 38.9% and 36.7% in 2024, reflecting stronger trade growth compared to the global average. The region's merchandise trade reached approximately US$18.5 trillion in 2024, representing growth of 5.1% and outpacing the WTO's global trade growth forecast of 2.6% [2]. This sustained expansion

of international trade—particularly in the Asia-Pacific region—has placed considerable pressure on existing transport infrastructures, especially on port facilities and their associated hinterland connections.

The expansion of manufacturing enterprises, the emergence of new industries, and the rising volume of supply and demand for maritime-related cargo have collectively necessitated the development of ports and the enhancement of cargo transit routes to these ports. This increasing demand has, in turn, resulted in higher cargo traffic volumes and a corresponding reduction in available terminal space. As container transport volumes continue to grow, the sea flow generates an almost proportional inland flow, making the links with the hinterland critical factors for seaport functionality. Consequently, there is an urgent need for port modernization and structural reforms to improve access to the hinterland. A dry port, defined as an intermodal terminal located in the hinterland and connected to one or more seaports via a high-capacity transport mode—such as scheduled rail services—can offer a comprehensive range of services typically provided at coastal ports, often with superior quality and enhanced operational efficiency [3]. Roso [3] argues that a well-applied dry port concept can help identify ways of shifting freight volumes from road to more energy-efficient traffic modes, relieve seaport cities of congestion, and facilitate improved logistics solutions for shippers in the port's hinterland. These services include cargo warehousing, empty container storage, container repairs, customs clearance, and cargo consolidation and support.

On the other hand, Iran's vast geographical expanse and the considerable distance between most major cities and coastal ports have created substantial challenges for exporters, importers, and transit cargo operations. Furthermore, the high cost of road transport has increased the final cost of domestic products, thereby diminishing the competitive advantage of Iranian producers relative to their foreign counterparts and adversely affecting the country's international trade performance. As coastal production costs in many countries rise, producers are moving inland to remain competitive, further emphasizing the need for efficient inland logistics solutions [4]. In addition to these economic challenges, severe traffic congestion in port cities and along the country's transport corridors—largely attributable to heavy truck movements—is a widely recognized problem [5]. Moreover, coastal cities and seaports, given their touristic nature, experience significant passenger traffic during certain periods of the year, which further exacerbates traffic congestion and, at times, leads to restrictions on truck movements and delays in cargo clearance from ports.

While certain operational issues—such as extended loading and unloading times and space shortages—may be addressed through targeted improvements, the more fundamental difficulties associated with truck congestion and urban traffic cannot be easily resolved through incremental measures alone [5]. Therefore, it appears that studying logistics systems such as dry ports could offer valuable insights for reducing congestion in ports and adjacent urban areas while simultaneously supporting broader regional development objectives. Roso and Lumsden [5] found that implementation of a dry port in a seaport's hinterland enables the seaport to increase its terminal capacity, while the modal shift from road to rail results in reduced congestion at seaport gates and improved inland access.

At present, various types of dry ports have been successfully established in numerous countries, where they play a pivotal role in improving and advancing transport conditions. Research has shown that dry ports are crucial to marine logistics, providing significant economic, environmental, and social benefits [6]. The strategic location of a dry port should satisfy at least three key criteria: (1) it should offer ease of access at a reasonable cost; (2) it should be situated in close proximity to production centers; and (3) it should be located within distribution clusters to facilitate efficient cargo handling and dispersion [4]. Notteboom and Rodrigue [4] note that the growing focus on inland/dry ports is indicative of transport development strategies gradually shifting inland to address capacity and efficiency issues in the light of global supply chains.

Recent studies on dry port implementation in Iran have begun to address these challenges. Hatami Nasab et al. [6] identified 17 key indexes for dry port implementation using a Delphi model, which were classified into eight groups, and validated a conceptual model using Partial Least Squares (PLS). Golghamat Raad and Rajendran [7], in a study tested on Iranian case data, suggested that high-capacity dry ports should be established in the cities of Sirjan and Tehran, while smaller dry ports should be built in Isfahan and Ahvaz, with connections to the national railway network for Chabahar and Anzali seaports. Similarly, research on the Zahedan dry port identified "reduction of road traffic" (mean = 3.65), "access to multimodal transport" (mean = 3.58), and "influx of private sector investment" (mean = 3.48) as paramount indicators, highlighting the critical need for infrastructure modernization [8]. However, challenges such as inadequate infrastructure, poor institutional coordination, and significant socio-economic inequalities limit the potential of these developments [7].

Accordingly, the development of dry ports may be considered an effective strategy for addressing these multifaceted challenges. The central research question that arises is: How can an efficient dry port be successfully established in Iran? In other words, what are the most critical factors influencing the successful implementation of a dry port in the Iranian context? This research, in addition to identifying these key

factors, aims to explore the interactive effects and causal interrelationships among them, thereby contributing to a more comprehensive understanding of the implementation pathway for dry port projects in Iran.

2. Methodology

This study employs a combination of descriptive and inferential statistical methods. Data collection was conducted through a structured questionnaire as part of a field-based research design, which also incorporated semi-structured interviews with subject matter experts. The questionnaire was developed following a comprehensive identification of dry port concepts and the key factors influencing regional economic development, which are briefly outlined in the subsequent sections. This mixed-methods approach, combining quantitative and qualitative data collection techniques, aligns with the framework proposed by Creswell and Creswell [9], who advocate for the integration of multiple data sources to enhance the robustness and depth of research findings.

2.1 Population and Sample

The target population of this study comprised university professors and academic specialists, maritime transport experts, logistics and multimodal transport professionals, and economic analysts from the Ministry of Roads and Urban Development, all of whom possess direct or indirect involvement with the Yazd Dry Port project. The minimum required sample size for identifying and ranking the factors affecting regional economic development and the establishment of Yazd Dry Port was determined to be 96 experts. This sample size calculation was guided by recommendations for multivariate analysis, which suggest a minimum ratio of 5 to 10 observations per variable [10]. In total, 105 questionnaires were distributed among the selected sample. Of these, 96 fully completed and valid questionnaires were deemed suitable for further statistical analysis and hypothesis testing.

2.2 Research Design and Analytical Framework

The overall analytical framework of this study incorporates both quantitative and qualitative dimensions. The quantitative dimension involves the application of specific statistical computations, while the qualitative dimension encompasses the interpretation, reasoning, and inference derived from the statistical results, ultimately enabling generalization to the broader population under investigation [9]. This integrated approach allows for a more comprehensive understanding of the complex interrelationships between dry port implementation and regional economic development.

The statistical procedures and methods employed in this study are outlined in Table 1.

Table 1. Statistical procedures and methods employed in this study

Analytical Step	Statistical Method / Test	Purpose
1	Kolmogorov–Smirnov (K-S) test	To determine whether the data follow a normal (parametric) or non-normal (non-parametric) distribution
2	Normality assessment	To verify distributional assumptions prior to parametric testing
3	Validity and reliability analysis	To ensure the internal consistency and construct validity of the measurement instrument
4	One-sample t-test	To compare sample means against a hypothesized population mean
5	Friedman test	To rank the relative importance of identified variables
6	Spearman's rank correlation coefficient	To examine the strength and direction of monotonic relationships between variables
7	Kruskal–Wallis H test	To compare differences across multiple independent groups (non-parametric alternative to one-way ANOVA)

The selection of these statistical techniques was informed by established methodological guidelines for social science research. Field [11] provides comprehensive guidance on the application of these tests within the SPSS environment, emphasizing the importance of testing underlying assumptions prior to parametric analysis. Similarly, Hair et al. [10] recommend the use of both parametric and non-parametric approaches to ensure the robustness of findings when distributional assumptions are uncertain.

2.3 Instrumentation and Data Analysis

All statistical analyses and graphical representations were performed using Microsoft Excel and SPSS version 19.0. The questionnaire instrument was designed based on an extensive review of the relevant literature and expert consultations. Prior to full-scale distribution, the questionnaire was pilot-tested to assess clarity, comprehensiveness, and appropriateness of the items, in accordance with the recommendations of Creswell and Creswell [9] for instrument development and validation.

2.4 Validity and Reliability

Content validity was established through expert review, wherein the questionnaire items were evaluated by a panel of academic and industry specialists to ensure that the constructs were adequately represented [10]. Reliability was assessed using Cronbach's alpha coefficient, with a threshold of $\alpha \geq 0.70$ considered acceptable for internal consistency [12]. Field [11] further notes that Cronbach's alpha values above 0.80 indicate good reliability, while values above 0.90

indicate excellent reliability. The specific reliability coefficients for each construct are reported in the Results section.

2.5 Ethical Considerations

All participants were informed of the research objectives and provided their voluntary consent prior to participation. Anonymity and confidentiality were guaranteed, and participants were assured that their responses would be used solely for academic research purposes. These procedures adhere to the ethical guidelines for research involving human subjects as outlined by Creswell and Creswell [9].

2.6 Limitations of the Methodology

While the chosen methodological framework provides valuable insights, several limitations should be acknowledged. First, the reliance on self-reported questionnaire data may introduce response [11]. Second, the cross-sectional design captures perceptions at a single point in time and does not account for temporal changes in the factors under investigation. Third, the generalizability of the findings may be limited to contexts similar to the Yazd Dry Port project. Future research could address these limitations through longitudinal designs and comparative case studies across multiple dry port locations.

2.7 Recommendations and Practical Implications

Following the analysis and interpretation of findings, a set of practical recommendations will be proposed. These recommendations are intended to serve as actionable insights for policymakers, transport planners, and infrastructure developers, as well as to provide a foundation for future research endeavors in the field of dry port logistics and regional economic development. The methodological approach employed in this study may also serve as a template for similar investigations in other developing countries seeking to implement dry port infrastructure.

3. Dry Port Typology and Characteristics

Based on their functional characteristics and spatial positioning, dry ports can be classified into three distinct categories: distant dry ports, midrange dry ports, and near dry ports. This typology reflects the varying geographical relationships between inland terminals and their associated seaports, as well as the differing operational and logistical roles they perform within the broader supply chain [13].

3.1 Distant Dry Ports

Distant dry ports represent the most common and historically established type of dry port, with a longer developmental trajectory compared to other categories. The primary rationale for utilizing this type of dry port is predominantly cost-driven: given the considerable distance from the seaport and the substantial volume of inbound cargo, rail transport emerges as a more economically viable and operationally efficient mode of transportation compared to road haulage [13]. Distant dry ports are typically located far inland, often in regions with high cargo generation or consumption, and serve as key nodes for consolidating and distributing freight over long distances [3].

A significant portion of the benefits associated with distant dry ports relates to the modal shift from road transport to rail networks, which consequently reduces congestion at seaport gateways and in their surrounding areas [3, 13]. The dry port concept is based on a seaport directly connected by rail to inland intermodal terminals, where shippers can leave and/or collect their goods in intermodal loading units as if directly at the seaport [3]. Each freight train can replace approximately 35 trucks in Europe and up to 100 trucks in the United States, thereby substantially mitigating the environmental externalities associated with road-based freight transport, including greenhouse gas emissions, air pollution, and road accidents [3, 14]. The primary rationale for collaboration between maritime seaports and distant dry ports is that through this integration, seaports can offer enhanced services at lower operational costs while simultaneously extending their coverage to a broader and more diversified hinterland [13].

Figure 1 illustrates the spatial relationship between a maritime seaport, its hinterland areas, and a distant dry port, demonstrating how the dry port functions as an extended gateway for cargo movement [13].

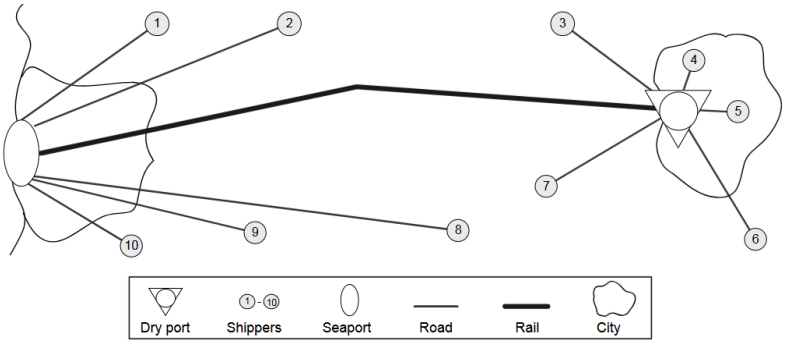


Figure 1. Schematic representation of a seaport, its hinterland, and a distant dry port [13].

3.2 Midrange Dry Ports

Considering the price-to-quality ratio of various transport systems, the competition between rail and road transport is largely contingent upon the geographical characteristics of the region and the spatial distribution of the population. Midrange dry ports are situated at a distance from the seaport where, as illustrated in Figure 2, road transport typically remains the predominant mode of access [13].

In this configuration, the midrange dry port functions as a consolidation center for rail services, serving as a strategic node where cargo from multiple origins is aggregated for efficient onward transportation. This arrangement demonstrates that specialized maritime transport management and equipment—such as X-ray scanning devices required for security screening and customs inspections—need only be present at a single terminal, rather than at every inland facility, thereby generating significant cost efficiencies. Consequently, the midrange dry port can effectively act as an intermediary, providing additional warehousing capacity for cargo that would otherwise be stored at congested seaport facilities [13].

Where warehouse space constraints exist at coastal ports, and provided that cost differentials are negligible, shippers whose locations are relatively equidistant from both the seaport and the dry port may be incentivized to route their cargo through the dry port rather than the congested seaport terminal. In other dimensions, the benefits of this type of dry port are broadly comparable to those associated with distant dry ports, including congestion reduction at seaport gateways, modal shift benefits, and extended hinterland coverage [13].

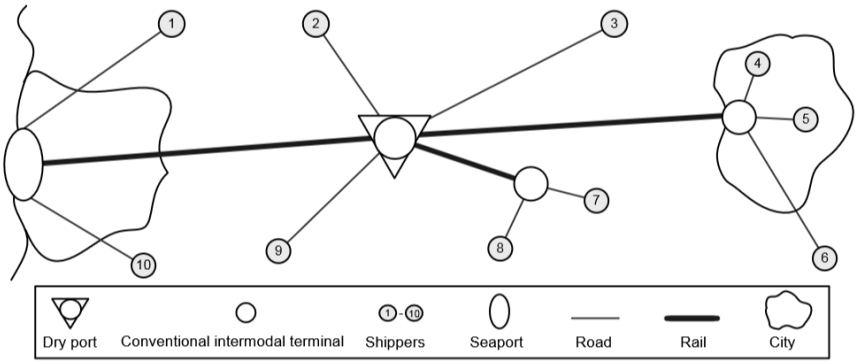


Figure 2. Schematic representation of a midrange dry port and its relationship to the seaport and hinterland [13].

3.3 Near Dry Ports

With the growth of container transport by sea, the primary challenges facing seaports are insufficient terminal space and inadequate access to inland transport networks. To effectively respond to the demands of shippers, seaports can establish near dry ports in their hinterland or in the suburban areas adjacent to the port city. By expanding container terminal capacity through the development of near dry ports, seaports can achieve increased operational efficiency and profitability while simultaneously accommodating the berthing of larger vessels [13].

Compared to other types of dry ports, near dry ports serve as a more effective intermediary for container handling and facilitate faster loading and unloading of container ships [15]. However, this function—particularly when aimed at preventing increased container dwell time—requires a reliable and well-integrated rail system to ensure seamless connectivity between the seaport and the near dry port [15].

Figure 3 illustrates a near dry port in relation to a seaport and a conventional intermodal terminal, demonstrating the spatial and operational relationships among these nodes [13].

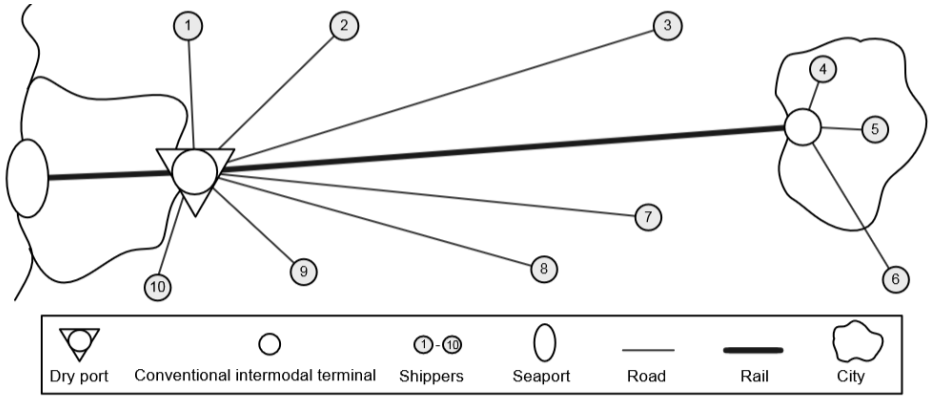


Figure 3. Schematic representation of a near dry port, seaport, and conventional intermodal terminal [13].

4. Literature Review

International research on dry ports has a considerably longer history compared to domestic studies. In Iran, despite numerous research efforts and policy decisions, executive actions remain limited. Therefore, this review examines the literature at both national and international levels.

4.1 National Studies

Dadvar et al. [16] investigated the importance of establishing dry ports for logistics development in Iran, concluding that the majority of services provided at seaports—including customs clearance, warehousing, container stripping and stuffing, and container repairs—can be effectively offered at dry ports. They further noted that dry ports serve as key cargo consolidation and distribution centers and play a significant role in intermodal and multimodal transport.

Sheikholeslami et al. [17] examined the impacts of dry ports on resolving seaport challenges, identifying insufficient warehousing space and inadequate access to cargo destinations as primary issues. They argued that dry ports offer solutions to these problems while providing additional benefits, including reduced road congestion, decreased fuel consumption, and lower land acquisition costs.

Saeidi et al. [18] explored the dry port concept with particular attention to Iran's needs. After reviewing the three dry port typologies—distant, midrange, and near—they concluded that dry ports can effectively reduce energy consumption, minimize environmental damage, alleviate seaport congestion, and improve logistical support for cargo vessels in hinterland areas.

Chahshouri et al. [19] conducted a feasibility study for establishing a dry port at Bushehr Port using SWOT analysis. They noted that globalization and increased competition have compelled ports to enhance efficiency through various strategies, including physical expansion and collaboration with international port operators. However, physical expansion is not always feasible, particularly in urban settings. Their findings indicated that Bushehr Port's current strategic position is characterized by weaknesses and opportunities (WO).

Hazeri et al. [20] analyzed the hardware, economic, and environmental factors influencing dry port establishment in Anzali Port. Using a Delphi method combined with DEMATEL and ANP techniques, they identified and prioritized key factors. Their results revealed that environmental factors ranked first, followed by economic factors and hardware infrastructure, with protection of fertile land emerging as the highest-priority individual factor.

4.2 International Studies

Beresford and Dubey [21] examined the environmental impacts of dry ports, concluding that efficient use of inland terminals and transport equipment can significantly reduce greenhouse gas emissions and pollutant discharge. Their research emphasized the modal shift from road to rail for inland transport between dry ports and seaports.

ESCAP [22] defined a dry port as an inland terminal for cargo consolidation and distribution, possessing characteristics similar to seaports, including customs services. Facilities available at dry ports include container handling equipment, intermodal transport infrastructure, presence of logistics service providers, and value-added services such as customs valuation, tax payment, warehousing, maintenance, banking, and ICT services.

Roso et al. [15] specified that beyond basic intermodal services, dry ports should provide cargo warehousing, empty container storage and repair, comprehensive customs services, and other related logistics functions.

Roso et al. [13] introduced the dry port concept and classified dry ports into three categories—distant, midrange, and near—concluding that the dry port concept facilitates modal shift from road to more energy-efficient and environmentally sustainable transport systems. Their research demonstrated that dry ports relieve seaport cities of congestion, reduce environmental impact, and provide advanced logistics capabilities in the hinterland.

The InterBaltic project [23] conceptualized dry ports as "extended gateways" for seaports, enabling control and regulation of cargo flows based on seaport conditions. This perspective emphasizes that dry ports are more closely related to organizational, service, and commercial needs within supply chains than to purely physical infrastructure.

ESCAP [24] concluded that dry port development can promote regional trade and serve as seaport equivalents for landlocked countries. Furthermore, dry ports directly contribute to intermodal transport development and sustainable transport systems through modal shift from road to rail.

Henttu and Hilmola [25] studied the financial and environmental effects of dry port structures in Finland. Using analytical models and linear integer programming, they estimated the benefits of implementing the dry port concept in Finland's transport network. Their findings demonstrated that relative transport costs can be significantly reduced by increasing the number of dry port distribution locations, with optimal benefits achieved at up to six locations. Gravity models confirmed that Finland benefits from dry port implementation.

Nguyen et al. [26] examined the spatial dynamics of dry ports in developing economies, concluding that these differ substantially from Western advanced economies due to geographic diversity, varying regional development speeds, and local practices. Their research indicated that dry ports in developing economies tend toward cluster formation rather than supply chain integration. The Indian government, for

example, expects dry ports to catalyze regional economic development, with their establishment predicated on the assumption that dry ports can become self-sustaining and generate spillover effects.

Witte et al. [27] addressed the relationship between dry ports and regional economic development, noting that the economic dimension of dry port development has received relatively little systematic attention at the local and regional levels. They called for further research on the regional economic development impacts of dry ports.

Liu et al. [28] investigated the relationship between dry ports and regional economies using a gravity model and predictive analysis of 1,040 observations across 104 cities along the Yangtze River Economic Belt from 2008 to 2017. Variables included economic indicators, logistics variables, foreign relations variables, and human capital variables. Their results demonstrated a positive correlation between dry ports and trade volume. GDP per capita, road area, railway infrastructure, and foreign relations variables showed positive correlations with trade volume, while human capital did not exhibit a significant effect. Government policy implications concerning dry ports and industrial clusters resulting from foreign investment were also highlighted.

4.3 Research Gap

The literature review reveals that although substantial international research has addressed various aspects of dry ports—including their classification, environmental benefits, and role in logistics—relatively limited attention has been paid to the regional economic development impacts of dry ports, particularly in the context of developing economies and landlocked regions [27]. Furthermore, while several Iranian studies have examined feasibility, site selection, and implementation factors, there remains a notable gap in quantitative empirical research specifically evaluating the economic impact of existing or proposed dry ports on their surrounding regions. The present study aims to address this gap by investigating the impact of Yazd Dry Port on regional economic development in Iran.

5. Key Infrastructure Indicators for Yazd Dry Port

Based on an extensive review of the existing literature—encompassing both national and international studies related to the research topic—and the results of an expert panel evaluation, a total of 11 key indicators were identified as influential factors in the establishment of Yazd Dry Port and its impact on regional economic development. These indicators are presented in Table 2 and serve as the analytical foundation for this study. Furthermore, these indicators were operationalized as the core items in the final research questionnaire, forming the basis for data collection and subsequent statistical analysis.

Table 2. Key Infrastructure Indicators for Yazd Dry Port Establishment and Regional Economic Development

No.	Indicator	Number of Sub-Indicators	Sources
1	Infrastructure availability	3	[18, 25]
2	Transit capacity	3	[17, 25, 13]
3	Security	2	[18]
4	Environment	2	[16]
5	Traffic congestion	4	[15, 16]
6	Centrality / Geographic position	5	[17]
7	Economic and financial factors	13	[17, 16, 25]
8	Employment and entrepreneurship	4	[29, 18]
9	Future development potential	9	[30, 25]
10	Accessibility	3	[18, 31, 16]
11	Proximity to production centers	3	[16]

Note. These indicators were derived from the literature review and validated through expert panel evaluation.

6. Data Analysis and Results

This section is dedicated to the analysis of data using descriptive and inferential statistical methods. Following the collection of research questionnaires and the organization of the obtained data, this section presents the analysis of the data. Initially, the findings derived from descriptive statistics (including background, age, educational level, and position) are reported. Subsequently, the descriptive findings related to the research variables are presented, followed by an assessment of the data distribution. In the inferential statistics section, SPSS software was utilized to examine and prioritize various factors within each dimension. For the hypothesis testing, the one-sample t-test was employed, and the Friedman test was used for ranking the factors. Additionally, confirmatory factor analysis was conducted. The significance level for all tests was set at $\alpha = 0.05$.

6.1 Questionnaire Distribution and Collection

In this study, a total of 105 questionnaires were distributed among university professors and academic specialists, maritime transport experts, logistics and multimodal transport professionals, and economic analysts from the Ministry of Roads and Urban

Development with involvement in the Yazd Dry Port project. Of these, 96 fully completed and valid questionnaires were deemed suitable for further statistical analysis and hypothesis testing.

6.2 Demographic Characteristics of Respondents

This section presents the demographic characteristics of the respondents, including age, educational level, and professional experience. As shown in Table 3, the majority of respondents (32.3%) were in the 41–50 years age bracket, followed by those under 30 years (25.0%), those aged 31–40 years (21.9%), and those over 50 years (20.8%). This suggests that the majority of participants have attained a sufficient level of intellectual maturity and professional expertise, making them well-qualified to provide informed responses on the subject matter.

Regarding educational attainment, the majority of respondents (47.9%) held a Bachelor's degree, followed by those with a Master's degree or higher (20.8%), a Higher National Diploma (HND) (18.8%), and a high school diploma (12.5%). This indicates that the respondents possess a relatively high level of formal education, enhancing the credibility and reliability of their responses.

With respect to professional experience, the majority of respondents (53.1%) had 5 to 10 years of professional experience, followed by those with 10 to 15 years (25.0%), those with more than 15 years (11.5%), and those with less than 5 years (10.4%). This indicates that the majority of participants possess sufficient practical experience in their respective fields, further strengthening the validity of their expert judgments.

Table 3. Demographic Characteristics of Respondents

Characteristic	Category	Frequency (n)	Percentage (%)
Age	Less than 30 years	24	25.0
	31–40 years	21	21.9
	41–50 years	31	32.3
	More than 50 years	20	20.8
Educational Level	Diploma	12	12.5
	HND	18	18.8
	Bachelor	46	47.9
	Master	20	20.8
Professional Experience	Less than 5 years	10	10.4
	5–10 years	51	53.1
	10–15 years	24	25.0
	More than 15 years	11	11.5
Total		**96**	**100.0**

Note. N = 96 respondents.

6.3 Normality Assessment of Data

Following the design of the main research questionnaire, it was distributed among the target population and collected. The data were then analyzed as described below.

A prerequisite for conducting all parametric statistical tests is the normality of the statistical distribution of the variables. In general, parametric tests are predominantly based on the mean and standard deviation. If the population distribution is not normal, accurate inferences cannot be drawn from the results. Therefore, this section first examines the normality of the variables using the Kolmogorov–Smirnov (K-S) test.

Table 4 presents the Kolmogorov–Smirnov test results for the observed variables included in the research model. As shown in the table, the skewness and kurtosis values for all variables fall within the acceptable range of –2 to +2. Consequently, it is concluded that the data distribution is normal, satisfying the assumption for parametric statistical tests.

Table 4. Kolmogorov–Smirnov Normality Test Results

Indicator	Skewness	Kurtosis
Infrastructure availability	–0.34	–0.16
Transit capacity	0.00	–0.03
Security	–0.37	–0.34
Environment	–0.15	–0.33
Traffic congestion	–0.40	–0.22
Centrality / Geographic position	–0.40	–0.27
Economic and financial factors	–0.26	0.29
Employment and entrepreneurship	–0.76	–0.63
Future development potential	–0.76	–0.67
Accessibility	–0.86	–0.37
Proximity to production centers	–0.53	–1.00

Note. Skewness and kurtosis values within the range of –2 to +2 indicate a normal distribution ([10, 11].

6.4 Inferential Analysis of Findings

In the inferential statistics section, the following tests were employed to accept or reject the research hypothesis:

Research Hypothesis: The effective infrastructure indicators of Yazd Dry Port have a positive and significant impact on regional economic development.

6.4.1 Factor Analysis of Questionnaire Data (Factor Loading Analysis)

Prior to testing the research hypothesis, the factor loadings of the items associated with each variable were examined to ensure the validity of the data for analysis. Factor analysis was employed to determine the factor loading of each component (questionnaire item).

KMO Test:

If the KMO value is less than 0.5, the data are not suitable for factor analysis. Values between 0.5 and 0.69 indicate moderate suitability, while values greater than 0.7 indicate that the correlations among the data are appropriate for factor analysis (Kaiser, 1974).

Bartlett's Test:

Bartlett's test of sphericity examines the null hypothesis that the observed correlation matrix belongs to a population with independent variables. For a factor model to be meaningful and useful, the variables must be correlated. Therefore, prior to factor analysis, a correlation matrix among the variables must be constructed. The correlation matrix is a square matrix of correlation coefficients between variables.

Table 5 presents the results of the KMO and Bartlett's tests. The KMO value was 0.77, indicating that the data are suitable for reduction to underlying factors and that the correlations among the data are appropriate for factor analysis. The significance level of Bartlett's test was less than 0.05, indicating that the correlation matrix is not an identity matrix. This means that there are high correlations among the components within each variable, while no significant correlations exist between components of different variables.

Table 5. KMO and Bartlett's Test Results

Test		Value
KMO Measure of Sampling Adequacy		0.77
Bartlett's Test of Sphericity	Approx. Chi-Square	686.36
	Degrees of Freedom (df)	91
	Significance (p-value)	0.000

Note. KMO > 0.7 indicates data are suitable for factor analysis. Bartlett's test $p < 0.05$ indicates the correlation matrix is not an identity matrix.

To determine the extent to which the measurement indicators (observed variables) are acceptable for measuring the latent variables, the minimum acceptable factor loading is 0.3 [32]. As shown in Table 6, the factor loadings for all components exceed 0.3, with values ranging from 0.62 to 0.89. Therefore, none of the questionnaire items were excluded, and all 52 items play a significant and determinative role in this research.

Table 6. Factor Loadings of Questionnaire Items

Indicator	Item No.	Factor Loading	Indicator	Item No.	Factor Loading
Infrastructure availability	1	0.73	**Employment and entrepreneurship**	33	0.73
	2	0.75		34	0.76
	3	0.76		35	0.82
Transit capacity	4	0.71		36	0.81
	5	0.74	**Future development potential**	37	0.77
	6	0.76		38	0.71
Security	7	0.80		39	0.74
	8	0.71		40	0.65
Environment	9	0.76		41	0.77
	10	0.69		42	0.84
Traffic congestion	11	0.73		43	0.75
	12	0.80		44	0.76
	13	0.85		45	0.75
Centrality	14	0.77	**Accessibility**	47	0.89
	15	0.64		48	0.79
	16	0.82		49	0.74
	17	0.72	**Proximity to production centers**	50	0.77
	18	0.80		51	0.79
	19	0.80		52	0.71
Economic and financial factors	20	0.71			
	21	0.78			
	22	0.73			
	23	0.78			
	24	0.87			
	25	0.83			
	26	0.80			
	27	0.83			
	28	0.69			
	29	0.73			
	30	0.79			
	31	0.74			
	32	0.62			

Note. All factor loadings exceed the minimum acceptable threshold of 0.3 [32], indicating that all items significantly contribute to their respective constructs.

6.4.2 Reliability Analysis of the Questionnaire

Reliability, or dependability, is one of the technical characteristics of a measurement instrument. This concept concerns the extent to which a measurement instrument yields consistent results under identical conditions. The reliability coefficient ranges from 0 to 1, and the closer this coefficient is to 1, the higher the reliability. In this study, Cronbach's alpha coefficient was employed to determine the reliability of the questionnaire. This method is used to calculate the internal consistency of the measurement instrument.

As shown in Table 7, the Cronbach's alpha values for all variables exceeded the acceptable threshold of 0.70, with the overall questionnaire achieving a Cronbach's alpha of 0.89. Therefore, it can be concluded that the questionnaire possesses good reliability, confirming that the data collected are suitable for testing the research hypothesis: *The effective infrastructure indicators of Yazd Dry Port have a positive and significant impact on regional economic development.*

Table 7. Reliability Coefficients (Cronbach's Alpha) of Research Variables

Variable	Item Numbers	Cronbach's Alpha
Infrastructure availability	1–3	0.76
Transit capacity	4–6	0.75
Security	7–8	0.73
Environment	9–10	0.82
Traffic congestion	11–14	0.83
Centrality / Geographic position	15–19	0.73
Economic and financial factors	20–32	0.76
Employment and entrepreneurship	33–36	0.72
Future development potential	37–46	0.73
Accessibility	47–49	0.75
Proximity to production centers	50–52	0.88
Total Questionnaire	**1–52**	**0.89**

Note. Cronbach's alpha values above 0.70 indicate acceptable internal consistency [12].

6.4.3 Hypothesis Testing

Research Hypothesis: The effective infrastructure indicators of Yazd Dry Port have a positive and significant impact on regional economic development.

To examine the effective infrastructure indicators of Yazd Dry Port on regional economic development—namely, infrastructure availability, transit capacity, security, environment, traffic congestion, centrality, economic and financial factors, employment and entrepreneurship, future development potential, accessibility, and proximity to production centers (shown in Table 8)—a one-sample t-test was employed. This test compares the mean of a variable against a specified value and determines whether the observed difference is statistically significant.

Since all questionnaire items were measured on a 5-point Likert scale, the hypothetical mean (test value) was set at 3 (the neutral/midpoint value). By comparing the obtained results, it is possible to determine whether there is a statistically significant difference between the mean of each variable and the midpoint value of 3.

The hypotheses for this test are:

H_0: There is no statistically significant difference between the variable mean and the midpoint value of 3.

H_1: There is a statistically significant difference between the variable mean and the midpoint value of 3.

Table 8. Descriptive Statistics of Infrastructure Indicators for Regional Economic Development

Indicator	N	Mean	Standard Deviation	Standard Error Mean
Infrastructure availability	96	3.33	0.99	0.10
Transit capacity	96	3.31	0.87	0.09
Security	96	3.75	0.74	0.08
Environment	96	3.39	0.81	0.08
Traffic congestion	96	3.47	0.74	0.08
Centrality / Geographic position	96	3.37	0.80	0.08
Economic and financial factors	96	3.60	0.55	0.06
Employment and entrepreneurship	96	3.43	1.41	0.14
Future development potential	96	3.42	1.20	0.12
Accessibility	96	3.56	1.27	0.13
Proximity to production centers	96	3.43	1.30	0.13

As shown in Table 9, the results of the one-sample t-test indicate that at the 99% confidence level, the significance level (p-value) for all variables is less than 0.05, and the t-statistic for all research variables exceeds the critical value of 1.96. Furthermore, there is a statistically significant positive difference between the mean of each infrastructure indicator and the midpoint value of 3. Therefore, it can be concluded that the infrastructure indicators of Yazd Dry Port have a positive and significant impact on regional economic development, and the research hypothesis is supported.

Table 9. One-Sample t-Test Results Comparing Mean Infrastructure Indicators Affecting Economic Development

Test Value = 3						
					95% Confidence	
Indicator	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Lower**	**Upper**
Infrastructure availability	3.28	95	0.00	0.33	0.13	0.53
Transit capacity	3.43	95	0.00	0.31	0.13	0.48
Security	9.98	95	0.00	0.75	0.60	0.90
Environment	4.67	95	0.00	0.39	0.22	0.55
Traffic congestion	6.27	95	0.00	0.47	0.32	0.62
Centrality / Geographic position	4.52	95	0.00	0.37	0.21	0.53
Economic and financial factors	10.60	95	0.00	0.60	0.48	0.71
Employment and entrepreneurship	2.98	95	0.00	0.43	0.14	0.72
Future development potential	3.40	95	0.00	0.42	0.17	0.66
Accessibility	4.27	95	0.00	0.56	0.30	0.81
Proximity to production centers	3.23	95	0.00	0.43	0.16	0.69

Note. df = degrees of freedom. A p-value < 0.05 indicates a statistically significant difference from the test value of 3. All variables show a positive mean difference, confirming a positive and significant impact on regional economic development.

6.4.4 Friedman Test Results for Ranking Infrastructure Indicators

The Friedman test was employed to prioritize and rank the infrastructure indicators of Yazd Dry Port affecting regional economic development based on their relative importance within the studied components. To examine the hypothesis that the rankings of the variables are equal, the following hypotheses were proposed:

H_0: The priorities of the variables are equal (there is no significant difference between the mean ranks of the variables).

H_1: At least two priorities are different (there is a significant difference between the mean ranks of the variables).

If the significance level (p-value) of the test statistic is less than the significance level ($\alpha = 0.05$), the null hypothesis is rejected, and the claim that the rankings of the variables are equal is not accepted. The ranking of the infrastructure indicators is presented in Table 10.

Table 10. Mean Ranks of Infrastructure Indicators

Indicator	Mean Rank	Rank Priority
Infrastructure availability	5.50	9
Transit capacity	5.24	11
Security	**7.04**	**1**
Environment	5.57	8
Traffic congestion	5.65	7
Centrality / Geographic position	5.40	10
Economic and financial factors	6.42	3
Employment and entrepreneurship	6.29	4
Future development potential	6.17	5
Accessibility	6.59	2
Proximity to production centers	6.13	6

As shown in Table 11, the significance level of the Friedman test statistic is 0.000, which is less than 0.05. This indicates a significant difference among the rankings. In other words, the alternative hypothesis (H_1)—that at least two priorities are different—is accepted, and the null hypothesis is rejected. It is noteworthy that the infrastructure indicators have varying impacts on the economic development of Yazd Dry Port, with security ranking as the most important factor among all components.

Table 11. Friedman Test Results

Test Statistic	Value
Sample Size (N)	96
Chi-Square (χ^2)	28.79
Degrees of Freedom (df)	10
Significance (p-value)	0.000

Note. A p-value < 0.05 indicates a significant difference among the rankings.

7. Discussion

The primary objective of this study was to investigate the impact of the infrastructure indicators of Yazd Dry Port on regional economic development. The findings provide empirical evidence supporting the research hypothesis that the effective infrastructure indicators of Yazd Dry Port have a positive and significant impact on regional economic development.

7.1 Interpretation of Findings

The one-sample t-test results (Table 7) revealed that all 11 infrastructure indicators had mean scores significantly above the midpoint value of 3, with p-values < 0.001 for all variables. The highest mean scores were observed for security (M = 3.75, t = 9.98), economic and financial factors (M = 3.60, t = 10.60), and accessibility (M = 3.56, t = 4.27). These findings suggest that from the perspective of experts and specialists, these three factors are the most critical infrastructure components influencing the economic development of the Yazd Dry Port.

The Friedman test results (Table 8) further corroborated these findings, with security ranking first (mean rank = 7.04), followed by accessibility (mean rank = 6.59) and economic and financial factors (mean

rank = 6.42). Conversely, transit capacity (mean rank = 5.24) and centrality (mean rank = 5.40) ranked lowest, indicating that while these factors remain significant, they are perceived as relatively less critical compared to other indicators.

The predominance of security as the highest-ranked factor is noteworthy. This finding aligns with the research of Saeidi et al. [18], who emphasized the importance of security in dry port operations, particularly given the high-value nature of containerized cargo and the need for customs inspection and anti-smuggling measures [13]. Security concerns at dry ports extend beyond physical security to encompass cargo integrity, customs compliance, and the prevention of illicit activities, all of which are fundamental to attracting international trade and investment [26].

The high ranking of accessibility is consistent with the dry port literature. Roso et al. [13] identified accessibility as a key criterion for dry port location, emphasizing that dry ports must be easily and economically accessible to serve their function as extended gateways for seaports. The fact that accessibility ranked second in this study underscores its critical role in ensuring efficient cargo flow between the dry port, seaports, and hinterland areas.

The third-ranked factor, economic and financial factors, reflects the findings of Henttu and Hilmola [25] and Liu et al. [28], who demonstrated that dry ports can significantly reduce transport costs and stimulate economic growth through enhanced trade volumes and foreign direct investment. The substantial number of sub-indicators under this dimension (13 items) in Table 1 further indicates its multifaceted nature, encompassing investment incentives, tax policies, financial institutions, and operational cost efficiencies.

The relatively lower rankings of transit capacity and centrality suggest that while these factors are essential, they may already be adequately addressed in the Yazd context or are perceived as less critical compared to other pressing concerns. However, this does not diminish their importance; as noted by Sheikholeslami et al. [17], transit capacity and geographical centrality remain fundamental to the strategic positioning of dry ports within national and international transport corridors.

7.2 Comparison with Previous Studies

The findings of this study are broadly consistent with international research on dry port economic impacts. Liu et al. [28], in their study of 104 cities along the Yangtze River Economic Belt, found that dry ports had a positive correlation with trade volume, and that GDP per capita, road infrastructure, railway infrastructure, and foreign relations variables positively correlated with trade volume. Similarly, the present study confirms that economic and financial factors, accessibility, and infrastructure availability are significant determinants of dry port success.

Witte et al. [27] noted that the regional economic development dimension of dry ports has received relatively little systematic attention. The present study addresses this gap by providing empirical evidence from the Iranian context, demonstrating that infrastructure indicators significantly contribute to regional economic development.

Nguyen et al. [26] observed that dry ports in developing economies tend toward cluster formation rather than supply chain integration. This is particularly relevant to the Yazd Dry Port, given its strategic location at the intersection of six national railway lines and its proximity to the special economic zone in Yazd province. The clustering effect may amplify the economic benefits identified in this study, as the concentration of logistics activities can generate synergies and spillover effects [23].

7.3 Theoretical Implications

This study contributes to the theoretical literature on dry port economics in several ways. First, it provides empirical validation of the conceptual framework proposed by Roso et al. [13], demonstrating that the three dry port typologies (distant, midrange, and near) can be operationalized through measurable infrastructure indicators. Second, it extends the work of Liu et al. [28] by applying their economic model to a new geographical context—Iran—thereby enhancing the generalizability of their findings. Third, it responds to the call by Witte et al. [27] for more systematic attention to the regional economic dimension of dry port development.

7.4 Practical Implications

The findings of this study have several practical implications for policymakers, transport planners, and infrastructure developers:

1. **Investment Prioritization:** Given that security, accessibility, and economic factors ranked highest, policymakers should prioritize investments in security infrastructure (surveillance systems, customs facilities, and cargo tracking), accessibility improvements (road and rail connectivity), and financial incentives (tax breaks, foreign investment facilitation).
2. **Public-Private Partnerships:** The challenges of government support limitations identified in this study suggest that public-private partnerships may be an effective mechanism for financing and operating dry port infrastructure. Clear delineation of responsibilities between government agencies and private operators is essential.
3. **Integrated Planning:** The importance of accessibility and centrality underscores the need for integrated transport planning that connects dry ports to national railway networks, highways, and

seaports. The Yazd Dry Port's location at the intersection of six railway lines provides a unique opportunity for seamless intermodal connectivity.

4. **Environmental Sustainability:** While environmental factors ranked eighth in the Friedman test (mean rank = 5.57), the modal shift from road to rail inherent in the dry port concept can significantly reduce carbon emissions [14]. Policymakers should leverage the environmental benefits of dry ports to attract international funding and comply with global sustainability standards.

7.5 Limitations of the Study

While this study provides valuable insights, several limitations should be acknowledged:

1. **Regional Specificity:** The findings are based on a single case study of Yazd Dry Port. The generalizability of the results to other Iranian dry ports or developing country contexts may be limited.
2. **Cross-Sectional Design:** The study employed a cross-sectional survey design, capturing perceptions at a single point in time. Longitudinal studies would be valuable to assess changes in infrastructure indicators and their economic impacts over time.
3. **Subjective Data:** The data were collected through self-reported questionnaires, which may be subject to response bias. Future research could incorporate objective economic indicators (GDP growth, employment statistics, trade volumes) to complement perceptual data.
4. **Limited Geographic Scope:** The study focused on a single province. Comparative studies across multiple dry ports in Iran (e.g., Sarakhs, Zahedan, Anzali) would provide a more comprehensive understanding of dry port economic impacts.

8. Conclusion

This study investigated the impact of 11 infrastructure indicators on the economic development of Yazd Dry Port. The findings confirm that all identified indicators have a positive and significant impact on regional economic development, with security, accessibility, and economic and financial factors emerging as the most critical determinants.

The strategic location of Yazd at the intersection of six national railway lines and its proximity to the special economic zone position it as a potential logistics hub capable of serving both national and international trade corridors. However, realizing this potential requires overcoming significant challenges, including limited government support, unclear executive frameworks, and coordination gaps among stakeholders.

The establishment of dry ports in Iran represents a very important opportunity for economic diversification, job creation, and sustainable development. With a better understanding of the environment and available tools, the implementation process can be accelerated, and the benefits of such ports can be fully realized. As developing countries increasingly turn to dry ports to enhance trade connectivity and regional economic growth, the insights from this study provide valuable guidance for policymakers, transport planners, and infrastructure developers in Iran and similar contexts.

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