Scientific and Social Research, 2025, Volume 7, Issue 6
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Analysis of Quantity and Weight Discrepancies in the Split Discharge of Imported Bulk Cargo at Two Ports in Shanghai, and Research on the Intelligent Application of Quantity and Weight Identification

Fei Qi, Zhizhong Wu, Wang Zhou, Minchao Zhang

Technical Center for Industrial Product and Raw Material Inspection and Testing of Shanghai Customs, Shanghai 201210, China

Abstract: This paper focuses on the prevalent issue of quantity and weight discrepancies that arise during the split discharge process at two ports after the import of iron ore at Shanghai port. Through the analysis of historical data from over 100 batches of imported iron ore, this study systematically reveals the multiple complex factors that contribute to these discrepancies. These factors include the inherent physicochemical properties of the cargo, environmental and operational impacts during transportation, and potential commercial fraud. Based on a thorough examination of the causes, this paper proposes a systematic response strategy involving multiple dimensions such as the intelligent identification of quantity and weight, optimization of operational procedures, harmonization of international standards, improvement of trade contract terms, and strengthening of regulatory cooperation. The aim is to provide decision-making references for enterprises involved in bulk cargo trade to effectively avoid risks and protect economic interests, while also offering valuable theoretical support and practical suggestions for relevant regulatory authorities to improve the inspection and supervision system for bulk cargo.

Keywords: Bulk cargo; Quantity and weight identification; Split discharge at two ports; Loading and discharging port discrepancies; Trade risks; Countermeasure research

Online publication: June 13, 2025

1. Introduction

Iron ore, as the cornerstone of the steel industry, plays a crucial role in global economic activities through its international trade. China is the world's largest consumer and importer of iron ore, and Shanghai port, as one of China's important gateway ports, handles a huge volume of iron ore import business every year. In the context of such large-scale trade, the issue of discrepancies in measured quantity and weight during the split discharge of cargo at two or more ports after entry is a long-standing and increasingly prominent problem. These discrepancies not only easily trigger complex international trade disputes but can also cause significant economic losses to importing enterprises. For example, according to statistics on quantity and weight identification conducted by Shanghai Customs for a certain enterprise, among the more than 100 batches of iron ore recently imported by the enterprise, the proportion of batches with weight shortages reached 30%, and the weight shortage rate of some ships even exceeded 10%. If not identified in a timely manner, it would directly result in huge economic losses for the enterprise.

The frequent occurrence of such incidents not only harms the legitimate rights and interests of importers but also has a negative impact on a fair and orderly international trade environment. Therefore, it is of great theoretical value and urgent practical significance to deeply and systematically analyze the specific causes of quantity and weight discrepancies in imported bulk cargo during cross-border transportation and multi-point split discharge, and to explore scientific and effective prevention and countermeasures based on this, proposing intelligent solutions. This study aims to reveal the physicochemical changes of bulk cargo during transportation through the analysis of actual cases and data, evaluate the impact of practical operations in quantity and weight identification, identify potential human factors, and finally construct a comprehensive framework for discrepancy management and control. This will provide a scientific basis for risk management in related enterprises and effective supervision by regulatory authorities.

2. Analysis of the causes of quantity and weight discrepancies in imported bulk cargo

Quantity and weight are the core basis for settlement in the international trade of bulk cargo, and discrepancies in these measurements involve multiple levels, such as natural factors, operational factors, and human factors.

2.1. Natural factors and physical losses

Moisture changes: Iron ore, especially fines, contains a certain amount of moisture. During long-distance ocean transportation, affected by climate, cabin temperature, ventilation, and other conditions, moisture evaporation or migration can occur, leading to differences in weight measurements between the discharge port and the loading port. Although moisture changes also affect quality, the direct reduction in total mass is an important natural factor for weight discrepancies [1].

Physical losses (in-transit losses): During various stages, such as loading, unloading, and transshipment (e.g., "second-leg transportation + transit + third-leg transportation" mode) of iron ore, physical losses due to spilling, dust emission, and adhesion to equipment or ship cabins are unavoidable. The more loading and unloading times and the longer the transportation chain, the greater the cumulative losses usually are. Prolonged loading and unloading operations (e.g., unloading 90,000 tons of fines takes about 60 hours) also increase exposure and loss opportunities.

2.2. Operational and technical factors

Water gauge measurement errors: Water gauge measurement is the primary method for determining the weight of bulk cargo, and its accuracy highly depends on the inspector's professional skills, experience, understanding of the ship's condition, and the rigor of data calculation. Any negligence in observation errors (such as reading errors, light/water surface fluctuation effects), inaccurate ship information, unclear measurement of ballast water/

oil-water, and calculation deviations of hogging and sagging deformations can lead to significant deviations in the final calculated weight [1]. Varying levels of inspectors from different ports and institutions are a common reason for discrepancies in water gauge measurement results between two ports.

Loading and unloading operation methods: When using grab buckets for bulk cargo loading and unloading, it relies on manual operation and can easily cause additional losses due to improper handling (such as spilling and impacting the hull). Differences in equipment conditions, management levels, and operational norms at different terminals can also affect the degree of loss. Differences in loading and unloading efficiency and conditions between inland river ports, such as the Yangtze River basin and seaports have also exacerbated weight discrepancies during split unloading processes.

2.3. Intentional behavior and trade fraud

Intentional short-loading: Some dishonest suppliers may exploit the dominance of weight measurement at the loading port or regulatory loopholes, resulting in actual loading quantities less than those specified in the bill of lading or contract, directly causing source-based short weight.

Fraud in the weight measurement process: During the water gauge measurement process, fraudulent activities such as falsifying ship information, deliberately concealing onboard inventories, and interfering with the measurement process may exist to obtain inflated loading weights [2].

3. Analysis of the causes of quality differences in imported iron ore

Quality is the key to determining the value of iron ore, and the differences in quality between loading and unloading ports are equally complex.

3.1. Inherent characteristics of the cargo and changes during transportation

Changes in moisture content and fluidization: Moisture not only affects weight but is also a key quality indicator. Fine-grained iron ore with a high moisture content is prone to moisture migration and seepage during bumpy ocean transportation, forming a "free liquid surface", which is a phenomenon known as fluidization. This not only changes the average moisture content of the cargo (possibly with a dry upper layer and a wet lower layer) but also poses a threat to navigation safety in severe cases (exceeding the transportable moisture limit, TML). Additionally, some terminals perform spraying and dust reduction operations due to environmental protection requirements, which can directly affect the surface moisture detection results during unloading.

Changes in chemical composition: Prolonged exposure to high-temperature and high-humidity marine environments can cause slow oxidation reactions in iron ore, affecting the determination of indicators such as Fe content. For special types of iron ore, such as direct reduced iron (DRI), improper moisture control (e.g., above 2%) can react with water (especially seawater) to produce hydrogen gas, altering the composition and posing a safety hazard [3].

Changes in physical form (Segregation/Stratification): Vibrations during ship navigation can cause rearrangement of ore components with different particle sizes and densities, leading to particle size segregation or chemical stratification. This makes samples taken from different locations or depths at the unloading port potentially different from those taken at the loading port (which are typically assumed to be uniformly mixed).

3.2. Differences in sampling and testing procedures

Representativeness of sampling: Sampling is the first step in quality inspection, and its representativeness is crucial. The sampling location (different parts and depths of the ship's hold), sampling method (manual/automatic, tool differences), sampling quantity, and frequency may follow different standards or habits at the loading and unloading ports. This can result in samples that do not equally represent the average quality of the entire shipment. Especially in cases of split unloading at two ports, there may be systematic differences in moisture, particle size, etc., between the upper layer samples taken at the first unloading port and the lower layer samples taken at the second unloading port. For ores with inherently high quality fluctuations, the differences can be more significant if strict sampling methods are not followed [4].

Non-uniform testing standards and methods: Despite the existence of international standards such as ISO, differences may arise in the specific implementation of standards (e.g., using different versions of the standards), equipment accuracy, operational procedures, and data processing methods across different countries and laboratories. Moisture (H_2O) testing, in particular, has a relatively high standardized interquartile range (0.36%) due to method sensitivity, making it one of the main sources of variation.

Testing timeliness: The timing of sample preparation and testing can also affect the results. For example, according to IMSBC rules, moisture testing should be completed within 7 days before loading. However, if the supplier provides an outdated report or if re-testing is not conducted after encountering rainy or snowy weather before loading, the report may not reflect the actual state during loading. Delays in testing at the unloading port may also lead to changes in the samples.

3.3. Human intervention and intentional adulteration

Selective sampling/submission: Suppliers may select better-quality ore samples at the loading port for testing to obtain a "favorable" quality report, concealing the true average quality of the entire shipment [5].

Adulteration: During the loading process, low-quality ore, impurities, or even water may be intentionally mixed in, or high-quality ore may be spread on the surface to cope with surface sampling.

Exploiting testing loopholes: Suppliers may exploit differences in testing agencies, standards, or time gaps to submit test results that are favorable to them. The lack of independent third-party supervision at some loading ports also provides room for manipulation.

4. Differential response strategies and systematic solutions

In response to the above causes, a comprehensive risk prevention and dispute resolution system needs to be constructed from multiple levels, such as technology, management, contracts, and regulations.

4.1. Technical level: Enhancing detection and monitoring capabilities

Intelligent water gauge measurement: Establish an intelligent platform for quantity and weight identification, integrating automatic calculation, smart observation of water gauges, historical data statistics, setting alarm thresholds, and automatically identifying high-risk cargo.

Online/rapid detection technology: Explore and apply technologies such as online moisture detection and rapid element analysis to achieve real-time or near-real-time monitoring of key indicators during loading and unloading, and promptly detect abnormalities [6].

Internet of Things and sensor technology: When feasible, use sensors to monitor cargo status (such as temperature, humidity, movement) and environmental changes during transportation, providing data support for analyzing the causes of differences.

4.2. Management and operational level: Standardizing processes and strengthening supervision

Standardized operating procedures: Promote the adoption of unified or compatible international standards (such as ISO) for sampling, sample preparation, and testing at loading and unloading ports, clarify operational specifications, and reduce methodological differences.

Optimizing logistics and reducing transfers: Reasonably plan transportation routes and modes, minimize unnecessary transfer links, and reduce physical losses and accumulated errors from multiple weighings.

Strengthening the entire process of supervision: Both trading parties can negotiate to appoint representatives or hire reputable independent third-party inspection agencies to supervise the entire process of loading, transportation, unloading, sampling, and testing to ensure operational compliance and data authenticity.

Improving professional literacy of personnel: Strengthen training and qualification management for inspection and appraisal personnel, ensure that they are certified to work, and continuously improve their professional skills and sense of responsibility.

4.3. Contractual and legal level: Clarifying rights, responsibilities, and risk allocation

Clarifying settlement basis: Clearly stipulate in the trade contract which independent and authoritative inspection agency's inspection certificate at which port (usually recommended to be the unloading port) will be used as the final settlement basis for quantity, weight, and quality.

Detailed quality clauses: Set more specific specifications, allowable error ranges, and reward and punishment mechanisms for indicators that are prone to disputes (such as moisture content, specific element content, and particle size) [7].

Agreeing on dispute resolution mechanisms: Clarify the handling process, re-inspection procedures, third-party arbitration, and other dispute resolution methods after differences occur.

4.4. Regulatory and cooperation level: Unifying standards and information sharing

Promoting international coordination of standards: Relevant international organizations and national regulatory authorities should strengthen cooperation to promote further harmonization and updating of standards related to iron ore sampling and testing.

Strengthening port supervision: Regulatory agencies such as customs at import and export countries should strengthen supervision of bulk cargo inspection and appraisal activities, combat trade fraud, and maintain a fair trade order.

Establishing an information sharing platform: Explore the establishment of an information sharing mechanism between ports, inspection agencies, and traders to improve transparency and jointly prevent risks (**Table 1**).

Table 1. Main causes and impact levels of weight discrepancies in iron ore

Type of discrepancy	Main cause	Typical discrepancy range/ characteristics	Preventability
Loss due to natural water evaporation	Cargo characteristics, transportation environment, duration	Can reach several per mille points (‰)	Medium
Physical loss during loading and unloading (In-transit loss)	Multiple transfers, operational normativity	Accumulates with increasing links	High
Error in water gauge measurement	Personnel skills, ship condition, methodology	Can be significant	Medium-high
Intentional short-loading/fraud	Dishonest behavior of suppliers	Variable proportion, can be large or small	High (strong supervision required)

5. Conclusion

The issue of quantity and weight discrepancies that arise during the loading and unloading of imported bulk cargo at two ports, as well as during the split unloading process between the two ports, is a complex and widespread problem in international trade practice. It involves multiple factors such as the natural properties of the cargo, changes in transportation conditions, operational technology levels, implementation of inspection standards, and business integrity. Through analysis, this study systematically summarizes the main causes of these discrepancies, including operational/technical factors such as errors in water gauge measurement and inadequate sampling representativeness, as well as human factors such as intentional short-loading or quality adulteration.

In response to these causes, this paper proposes a multi-dimensional and systematic framework of countermeasures. It emphasizes that the introduction of intelligent detection technologies (such as automatic water gauge reading identification, automated calculation, and smart observation equipment), standardization of operational processes (unified sampling and testing standards, optimized logistics), improvement of trade contract terms (clarifying that unloading port inspection is the standard, refining quality requirements), and strengthening domestic and international regulatory cooperation and information sharing can effectively prevent and reduce the occurrence of discrepancies. When discrepancies occur, these measures provide a clear path for resolution [8].

The analysis and recommendations of this study can serve as a reference for enterprises engaged in the import business of bulk cargo in contract negotiation, risk assessment, process management, and other aspects, helping them to protect their legitimate rights and interests. At the same time, it also provides ideas for customs and other regulatory authorities to improve relevant regulations and policies and enhance regulatory effectiveness. However, the bulk cargo trade involves many links and dynamically changing influencing factors. This study may have limitations in data sources, and further research combining more real-time data and cases is still needed in the future. In particular, evaluating the application effects of emerging technologies and comparing practical differences among different trading partners will be worthwhile directions for further exploration. The ultimate goal is to jointly promote a more fair, transparent, and efficient international trade environment.

Funding

Project number: SHK003-2024

Project name: Research on the intelligentization of the number and weight identification of bulk commodities at Shanghai Port

Disclosure statement

The authors declare no conflict of interest.

References

[1] Zhang QY, 2025, Research on the Application of Intelligent Monitoring Systems in Port Safety Management. Water Safety, 2025(6): 172–174.

[2] Tu S, Shi HK, 2025, Accelerating the Research and Application of Vehicle Autonomous Driving Technology in the Port Sector. China Ports, 2025(1): 23–26.

[3] Han ZY, 2024, Discussion on the Intelligent Application of Port Grain Storage. Modern Food, 30(20): 5–11 + 121.

[4] Chen JF, Zhong WJ, Wang T, et al., 2024, Inspection Methods and Research Applications for Remote and Automatic Control Systems of Intelligent Port Cranes. Construction Machinery Technology and Management, 37(5): 57–60.

[5] Wang X, 2024, Research and Application of Optimization Algorithms for Intelligent Port Coal Yard Scheduling Systems. Software, 45(7): 80–82.

[6] Li QZ, Zhao ZY, 2023, Research on an Intelligent Management System for Hot Work Operations Involving Hazardous Goods at Ports. Transport Manager World, 2023(29): 164–166.

[7] Wang SJ, 2023, Research on Ship Intelligent Management System Based on Internet of Things Technology. Pearl River Water Transport, 2023(15): 88–90.

[8] Huang ZZ, Xu MC, 2021, Prospects and Applications of Intelligence in Oil and Gas Chemical Terminals. Labor Protection, 2021(2): 91–93.