CHINA'S APPROACH TO SMART CONTAINER:

TECHNOLOGY ADOPTION, DATA GOVERNANCE, AND IMPLICATIONS FOR GLOBAL LOGISTICS

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Abstract

The digitalisation of containerised maritime transport is widely presented as a mechanism for improving visibility, operational efficiency and supply chain security. However, the global diffusion of track-and-trace technology for containers remains uneven and insufficiently explained in existing research. China, as the largest container manufacturing nation and a central actor in maritime logistics, occupies a critical but empirically underexamined position in this development. Current literature provides only partial accounts of China's digitalisation trajectory and offers limited insight into how policy ambition, institutional structures and organisational incentives influence the evolution of smart container technologies.

This study investigates China's approach to integration of the track-and-trace capabilities into the global container ecosystem. Four objectives guide the research. The first objective is to clarify, through a critical review of existing academic literature, how Chinese container digitalisation has been conceptualised and where analytical gaps persist. The second objective is to examine empirically the Chinese approach to applying track-and-trace technology on Chinese owned containers operating in global logistics, based on qualitative evidence from semi-structured interviews. The third objective is to evaluate Chinese perspectives on data ownership and data sharing within the digitised supply chain, a domain that shapes both domestic coordination and international interoperability. The fourth objective is to interpret the empirical findings within the context of China's industrial policy goals, to clarify how *Made in China* strategies shape container-level digitalisation.

Empirical data were generated through semi-structured interviews conducted in Chinese with senior figures from shipping lines, container manufacturers, technology providers

and national standardisation bodies. The use of the original language ensured accurate representation of meanings and cultural nuance during the analysis process.

The findings show that China's digitalisation agenda presents a clear strategic rationale at the policy level but displays fragmentation in operational practice. Adoption decisions are shaped by ownership configurations, divergent commercial incentives, legacy operational routines and technological constraints. Data governance reflects a combination of sovereignty oriented regulatory principles and context dependent contractual arrangements. Standardisation efforts reveal institutional competition and technical divergence that complicate international interoperability.

The study contributes to academic debate by applying developmental state theory, the technology-organisation-environment framework, institutional theory and data governance research into the empirical case of container digitalisation. This research clarifies how state driven industrial ambition interacts with organisational decision making in a global transport system. The study also provides practical insight into the structural factors that influence the adoption of smart container technologies originating from China and their implications for global logistics digitalisation.

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List of Tables and Figures

Figure 2.1: Literature Review Chapter Structure……27

Table 2.1: Matching Research Objectives with Literature Gaps and Research Questions……..... 67-68

Table 3.1: Theoretical Framework Matrix……..… 88

Table 4.1: Comparison among Research and Interview Questions with Research Objectives……...102-103

Table 4.2: Interviewees Profile……. 111-114

Table 4.3: Codebook based on Mayring (2000)…… 123-125

Table 4.4: Steps of Thematic Analysis by Authors and the Steps Chosen for This Research…….130-132

Table 5.1: Findings per Research Question…… 375-390

Table of Contents

ABSTRACT **1**

ACKNOWLEDGEMENTS **3**

LIST OF TABLES AND FIGURES **4**

TABLE OF CONTENTS **5**

1 INTRODUCTION **8**

1.1 Structure and Scope Overview of Introduction to the Chinese Smart Container Study 8

1.2 Background to the Chinese Smart Container 9

1.3 Research Problem and Business Context 10

1.4 Research Aim and Objectives 11

1.5 Market Context Analysis - Grey and Professional Literature Review of Chinese Smart Container Development 12

1.6 Scope of the Study 16

1.7 Specificity and Contribution of the Project 17

1.8 Research Rationale 20

1.9 Research Challenges ..... **Error! Bookmark not defined.**

1.10 Structure of the Study 21

1.11 Summary and Conclusion of Introduction to the Study 23

2 LITERATURE REVIEW **25**

2.1 Introduction of the Academic Landscape on Container Digitalisation 25

2.2 Literature Search Strategy 28

2.3 Made in China 2025 as China's Strategic Interpretation of Industry 4.0 30

2.3.1 Maritime Silk Road within China's Digital Industrial Strategy 35

2.4 Global Smart Container Adoption 39

2.4.1 Conceptual and Technological Foundations of Digitalisation 43

2.4.1.1 Internet of Things in Container Tracking 46

2.4.1.2 Approach to Data Handling and Chinese Specifics 50

2.4.2 Influence of the Chinese Smart Container Adoption 55

2.5 Research Gaps and Research Questions 57

2.6 Summary and Conclusion of the Academic Landscape on Container Digitalisation 63

3 THEORETICAL FRAMEWORK **69**

3.1 Positioning the Theoretical Framework within the Study 69

3.2 Developmental State Theory and Strategic Industrial Policy 72

3.3 Technology-Organisation-Environment (TOE) Framework 75

3.4 Data Governance and Sovereignty Framework 77
3.5 Institutional Theory and Geopolitical Digitalisation 80
3.6 Summary and Conclusion of the Theoretical Framework 84

4 RESEARCH METHODOLOGY 89

4.1 Framing the Methodological Approach and Chapter Structure 89
4.2 Research Philosophy 91
4.2.1 Research Ontology 92
4.2.2 Constructivist approach 93
4.2.3 Epistemology 95
4.3 Research Design 96
4.3.1 Research Method 97
4.3.2 Qualitative Research based on a combined Approach: Grounded Theory Elements with Constructivist Interpretation 98
4.3.3 Semi-structured interviews 101
4.3.4 Thematic qualitative text analysis 103
4.4 Data Collection 106
4.4.1 Introduction 106
4.4.2 Sampling 108
4.4.3 Data Collection: Interview Protocol and Interview Guide 116
4.5 Data Analysis Method 118
*4.5.1 Introduction ..... **Error! Bookmark not defined.***
4.5.2 Coding the Data 120
4.5.3 Intercoder Reliability 128
4.5.4 Self-Reflection 129
4.5.5 Researcher Bias 135
4.5.6 Recording and Transcription 137
4.5.7 Analysing the Data 138
4.6 Ethical Considerations 142
4.7 Summary and Conclusion of the Research Methodology 144

5 FINDINGS OF THE CHINESE SMART CONTAINERS DEVELOPMENT 147

5.1 Introduction to the Data Analysis Results 147
5.2 Smart Container Market Penetration and its Influence on the Supply Chain 148
5.3 Data Governance and Sovereignty 152
5.4 Governmental Stimulation of the Chinese Smart Container 156
5.4.1 Approach to Digitalisation: Strategic Vision versus Market Caution 156
5.4.2 Implementation Challenges: Cost, Battery, and Technical Viability 158

5.4.3 Standardisation: National Alignment and Global Aspirations 160
5.4.4 Governmental Support: Fragmented and Indirect 164
5.4.5 Technology Origin 167
5.4.6 Identified Patterns in Findings on Data Governance and Sovereignty 170
5.4.7 Summary of Governmental Stimulation of the Chinese Smart Container 173
5.5 Summary and Conclusion of the Findings 175

6 DISCUSSION OF THE CHINESE SMART CONTAINER DEVELOPMENT 179

6.1 Framing the Discussion and Analytical Structure 179
6.2 Smart Container Market Penetration and its Influence on the Supply Chain 180
6.3 Data Governance and Sovereignty 189
6.4 Governmental Stimulation of the Chinese Smart Container 193
6.4.1 Approach to Digitalisation: Strategic Vision versus Market Caution 196
6.4.2 Implementation Challenges: Cost, Battery, and Technical Viability 198
6.4.3 Standardisation: National Alignment and Global Aspirations 200
6.4.4 Governmental Support: Fragmented and Indirect 202
6.4.5 Technology Origin 204
6.4.6 Identified Patterns in Data Governance and Sovereignty 206
6.4.7 Summary of Discussion on Governmental Stimulation of the Chinese Smart Container 208
6.5 Summary and Conclusion of the Discussion 212

7 CONCLUSION OF THE CHINESE SMART CONTAINER STUDY 217

7.1 Overview of the Study Conclusions 217
7.2 Addressing the Research Aim 217
7.3 Academic Contribution and Theoretical Advancement 219
7.4 Managerial and Policy Implications 224
7.5 Addressing Quality Criteria of the Study 229
7.6 Limitations and Areas for Future Research 232
7.7 Final Summary and Reflective Conclusion 234

DECLARATION OF AUTHENTICITY 237

REFERENCES 238

APPENDICES 270

Appendix I Letter of Consent, English/Chinese 270
Appendix II Interview Transcripts 274
Appendix III Table Comparison of Research Questions to Codes and Quotes 375
Appendix IV Selected Screenshots of the Interviews Coding and Intercoder Reliability, Nvivo and Atlas.ti Programmes 391

1 Introduction

1.1 Structure and Scope Overview of Introduction to the Chinese Smart Container Study

This chapter establishes the conceptual, empirical and methodological foundations upon which the study is built. The Chapter introduces the maritime digitalisation context that frames the research problem, explains why the container as a digitally enabled asset warrants analytical attention and clarifies the strategic significance of focusing on China as the world's dominant container nation. The chapter's purpose is to orient the reader to the rationale for the investigation, define the research aim and objectives and set out the contours of the methodological approach that informs the study's empirical and theoretical development.

The chapter proceeds in a structured manner to ensure clarity and analytical coherence. The background Section 1.2 situates Chinese container digitalisation within wider transformations in global logistics and outlines China's expanding influence in shaping the digital trajectory of maritime transport. This is followed by an examination of the research problem and its business relevance in Section 1.3, identifying the empirical and conceptual gaps that necessitate the study. The research aim and objectives in subchapter 1.4 are then presented in a manner that links the conceptual concerns to the subsequent empirical inquiry.

To contextualise the study within current industry practice, the chapter incorporates a review of professional and grey literature on Chinese smart container development in Section 1.5. This provides a contemporary market perspective that complements the academic literature review found in Chapter Two. The chapter also defines the scope of the research in Section 1.6 by setting out the boundaries of the inquiry, identifying the specific elements of container digitalisation examined and making explicit the areas that are deliberately excluded. This Chapter concludes by outlining the rationale for the study

(1.8) and by presenting the distinct set of challenges (1.9) that arise when researching a politically sensitive and institutionally complex domain.

The Chapter then introduces the Structure of the Study in Section 1.10, which maps how the thesis progresses from contextual and theoretical framing to methodological justification, empirical analysis and conceptual synthesis across Chapters Two to Seven. The final section 1.11, Summary and Conclusion of Introduction to the Study, draws together the key arguments made in this introductory Chapter, restates how the research's aim and objectives are grounded in the Chinese container context and indicates how the subsequent literature review develops the intellectual foundations for the study.

1.2 Background to the Chinese Smart Container

Maritime transportation remains a foundational component of global trade, facilitating more than eighty percent of international goods movement and shaping patterns of economic development and environmental sustainability (World Bank Group, 2025). China has emerged as a central actor in this system. China is rapidly expanding investments in ports, terminals and container fleets, together with its control of approximately one hundred port facilities across more than sixty localities worldwide, provide the capacity to generate and utilise unprecedented volumes of real-time container movement data (Rochat, 2021). This infrastructure strengthens China's influence within global logistics and positions the PRC as a significant driver of digital transformation in maritime transport.

Digitalisation has become a defining characteristic of contemporary supply-chain evolution. Advances in information and communication technologies, the integration of big-data analytics and the demand for transparency and traceability have accelerated the adoption of new forms of operational intelligence (Rosenberg, 2020). Amongst these developments, the smart container has gained prominence. Equipped with Internet of Things (IoT) devices, smart containers have the potential to improve operational efficiency, enhance supply-chain visibility and strengthen cargo safety and regulatory compliance (Wang & Sarkis, 2021). Despite these anticipated benefits, global uptake of container-level IoT remains fragmented, selective and uneven, with adoption shaped by cost, institutional capacity, regulatory environments and geopolitical constraints.

China's position in this landscape is distinctive. The country's strategic commitment to logistics digitalisation, combined with its pivotal role in containerised trade, places the PRC at the centre of technological experimentation and policy development in this domain (Zhang et al., 2025). Understanding how China integrates track-and-trace IoT technology into its container fleets therefore provides an opportunity to examine not only the potential benefits of digitalisation but also the institutional, geopolitical and interoperability challenges that accompany it. This study investigates how Chinese industry and policy actors conceptualise and operationalise smart container technologies and how these practices influence global supply-chain governance.

1.3 Research Problem and Business Context

Although digitalisation has been widely examined in ports, terminals, and related maritime infrastructures (Rochat, 2021), the container itself as the fundamental operational unit of global trade remains comparatively underexplored in academic research. Researchers studying logistics digitalisation tend to focus on broader system-level transformations, such as smart ports, blockchain-enabled trade platforms, or national logistics strategies (Rosenberg, 2020; Wang & Sarkis, 2021). By contrast, research that investigates the digitalisation of the container as a discrete asset is noticeably limited. Given China's extensive role in manufacturing containers, owning port infrastructure, and influencing supply chain digitalisation (Rochat, 2021; Zhang et al., 2025), this represents a significant gap in the literature.

From a research perspective, existing academic work often interprets Chinese digitalisation through the lens of large-scale infrastructure programmes or geopolitical strategy (Zhang et al., 2025; Rosenberg, 2020). While these analyses illuminate high-level motivations, they rarely explain how policy, ownership structures, and institutional arrangements shape digitalisation in China at the container level. It is therefore reasonable to assume that the current literature provides only a partial understanding of how China interprets and operationalises track-and-trace IoT technologies within its container logistics sector. Wang and Sarkis (2021) have noted that without examining these organisational and institutional mechanisms, explanations of digitalisation risk becoming overly abstract.

From a business perspective, companies engaging with Chinese logistics and technology actors could face different expectations around data governance, sovereignty, and standardisation. This observation emerges from reviewing of China's data sovereignty laws, including the Data Security Law and the Personal Information Protection Law, which place strict conditions on cross-border data transfer and data handling (DSL, 2021; The National People's Congress of the People's Republic of China, 2021). Given these regulatory conditions, it can be assumed that multinational shipping companies, technology providers, and regulators require clearer analytical guidance on how to collaborate with Chinese partners and how to ensure interoperability in shared digital environments. Wang and Sarkis (2021) also indicate that such guidance is currently limited.

Overall, the research problem addressed in this study arises from this dual gap. Empirically, there is insufficient understanding of how Chinese actors adopt, interpret, and regulate container digitalisation. Practically, international companies could lack a conceptual basis for navigating China's institutional and regulatory landscape when engaging in cross-border digital collaboration, needed for the international supply chain operations. This study responds to both challenges by investigating how Chinese industry and policy actors conceptualise, operationalise, and govern container digitalisation within the wider context of national industrial transformation.

1.4 Research Aim and Objectives

The overarching aim of this research is *to investigate China's digitalisation solutions for integrating track-and-trace technology into the global container ecosystem*.

This aim reflects the core research problem identified in Section 1.3, namely the limited empirical and conceptual understanding of how container digitalisation evolves within China's distinctive political economy, regulatory environment and institutional structure. Because China is the world's leading container nation and a central actor in global logistics, examining its digitalisation practices provides an opportunity to understand how technological ambition, data governance and organisational decision-making shape the wider transformation of containerised transport.

To address this aim, the study establishes four interrelated objectives that collectively structure the analytical pathway of the study. The ***first objective*** is to identify, through a critical review of the academic literature, how track-and-trace technology has been conceptualised and adopted within Chinese container maritime transportation. This objective provides the theoretical and empirical foundation for the research by situating existing debates, identifying gaps and clarifying how China's digitalisation trajectory has been interpreted. The ***second objective*** is to analyse empirically the Chinese approach to using track-and-trace technology on Chinese-owned containers operating in global logistics, based on primary qualitative data gathered through semi-structured interviews. This enables the study to examine how national strategy, organisational priorities and commercial realities intersect at the operational level. The ***third objective*** is to evaluate the Chinese perspective on data governance related to smart container within the digitised supply chain, again drawing on qualitative evidence. This objective is essential because data governance has emerged as a defining dimension of digital transformation, shaping both domestic coordination and international interoperability. The ***fourth objective*** is to interpret the empirical findings within the context of China's industrial policy goals, to clarify how *Made in China* strategies shape container digitalisation. This objective extends the analysis by linking the empirical findings to theoretical advancement and by identifying broader implications for global logistics digitalisation.

Together, these objectives operationalise the research aim by guiding the study from conceptual clarification to empirical investigation, to theoretical synthesis. The identified four objectives ensure coherence across the study's design and provide the structure through which the research aim is addressed in the subsequent chapters.

1.5 Market Context Analysis - Grey and Professional Literature Review of Chinese Smart Container Development

To critically assess China's emerging role in the global smart container deployment, this section draws upon professional literature to synthesise commercial trends, strategic investments, and institutional developments. The analysis is anchored in China's dual position as both a dominant maritime nation and the primary manufacturer of containers

globally, examining how these structural advantages shape its smart container strategy and influence global logistics digitalisation.

As of 2024, China remains the world's largest exporter, according to recent WTO figures (WTO, 2025). This position reinforces the state's long-term strategy to consolidate and expand globally competitive logistics entities, such as China Ocean Shipping Company (COSCO), China Shipping Corporation (CSCO), and China Merchants Group. The consolidation efforts are evident in COSCO's acquisition of Hong Kong-based Orient Overseas Container Lines (OOCL) in 2018, when COSCO acquired a controlling share of the company (World Maritime News Staff, 2018). By 2022, COSCO and CSCO were jointly operating both domestic and international shipping routes, accounting for approximately eighty percent of China's domestic containerised shipping market (Pierce, 2020). Currently, COSCO ranks as the fourth largest container shipping company globally, with a reported fleet of 3,369,473 twenty-foot equivalent units (TEUs) and a market share of 10.5 percent (Nikolakis, 2025).

Once digitised, this extensive fleet has the potential to fundamentally reshape global data flows, standards, and infrastructure dependencies in maritime trade. Parallel to its shipping dominance, China also exerts a near-monopolistic position in container manufacturing. According to the U.S. Federal Maritime Commission, Chinese companies produce over 95 percent of the global container fleet, led by CIMC with an annual output of two million units, and COSCO Shipping Development producing an additional 1.3 million units (Bentzel, 2022; X-Change, 2023; Joy, 2025). This control over physical production creates a strategic gateway for embedding IoT solutions at scale.

During this time, key Chinese manufacturers have begun embedding digital capabilities into their production lines. CIMC, through subsidiaries such as CIMC AIoT and CIMC HiTech, now integrates tracking and sensor technology into new container builds (CIMC, 2024; Telenor IoT, 2018). Similarly, BoxPlus, a COSCO-backed venture incubated at Shanghai Maritime University, specialises in IoT solutions tailored to COSCO's fleet, offering proprietary visibility platforms (BoxPlus, 2025). These developments illustrated the emergence of a vertically integrated digital container ecosystem that aligns physical infrastructure, data services, and national strategic priorities.

However, concerns have emerged regarding the governance of the smart container. Reports from the U.S. Federal Maritime Commission and other regulatory sources indicate that both CIMC and COSCO are ultimately controlled by state-owned conglomerates such as China Merchants Group (Bentzel, 2023). This raises critical questions around data sovereignty, commercial neutrality, and the use of container-level digital infrastructure in the service of geopolitical objectives.

While global digitalisation trends are accelerating, China's domestic rollout of smart containers appears comparatively modest. COSCO has reported the digitalisation of 100,000 refrigerated container units, with plans for dry containers in development (China COSCO Shipping Corporation Limited, 2024). However, this represents only a small fraction of its total fleet of 3,369,473 TEUs. Furthermore, there is limited evidence that Chinese IoT providers have penetrated the international market beyond China's borders. In contrast, Western IoT solution providing companies such as Nexxiot (Switzerland), Orbcomm (USA), and Hoopo Systems (Israel) have made significant commercial inroads, particularly with full fleet digitalisation projects for shipping lines (Bruno, 2022; Uliel-Mirkin, 2024).

The phenomenon of smart container has increased its speed since the German shipping line Hapag Lloyd decided to digitise their full fleet, including both refrigerated containers and dry container types (Bruno, 2022). Hapag Lloyd ranked in 2025 as the fifth largest line with 7.5 percent of the market operates globally close to 2.5 million containers (Nikolakis, 2025). Hapag-Lloyd's full-fleet digitalisation marked a significant shift in traditional container operations, using daily data harvesting to optimise efficiency, reduce delays, and cut emissions (Bruno, 2022). Israeli carrier ZIM described its smart container rollout as central to its innovation strategy (Uliel-Mirkin, 2024), suggesting that smart container adoption is not a transient experiment but a long-term strategic commitment. In illustrating this growth, Hapag-Lloyd outfitted its 1.6 million dry containers with Nexxiot and Orbcomm IoT solutions (Bruno, 2022). ZIM also partnered with Hoopo Systems to equip its fleet with solar-powered IoT devices offering real-time, multimodal visibility (Uliel-Mirkin, 2024). These developments indicate that international adoption is being led by Western companies, with little evidence of Chinese IoT solutions being used outside of China.

Following the global technological shift toward IoT-enabled containerisation, it is critical to understand how these technologies are being adopted and operationalised across the logistics value chain. The container operating environment must be clearly mapped by identifying the key stakeholders who enable or influence their digitalisation. These include shipping lines, port operators, technology providers, and customs or regulatory authorities. Shipping lines such as Maersk and Hapag-Lloyd have been early adopters of the IoT technology and digitised their fleet to attain efficiency and visibility (Campbell, 2022; Bruno, 2022). Port operators like PSA in Singapore and the Port of Rotterdam provide both the physical and digital infrastructure to support IoT systems, including smart yard management and interoperable Port Community Systems (DCSA, 2025; PSA International, 2022), along with technology providers, who serve as enablers of the smart container project (Barakat, 2025). Mapping the roles of early adopters and infrastructure providers can highlights how smart container adoption is not solely a technological shift, but a logistics industry wide transformation that creates new expectations, partnerships, and operational baselines shaping the global supply chain landscape.

Interest in container digital twins and the interoperability enabled by real-time tracking has begun to emerge in both industry analyses and early academic discussions (Markets and Markets, 2022; Papagiannidis & Marikyan, 2020). Container digitalisation technologies claim to allow not only improved visibility but also automated alerts and advanced analytics for sensitive cargo, such as temperature excursions (Campbell, 2022). The transformation from conventional to smart containers might shape a new industry benchmark, signalling a probable operational shift from niche innovation to infrastructure standard. Complementing commercial initiatives are international standardisation efforts. ISO Technical Specification 25287 (2025) outlines functional and identification requirements for smart containers, formalising their role in the global supply chain (ANSI, 2025). The new ISO specification ought to update the ISO 830:2024 further classify containers by technological features such as integrated power and sensor systems (ISO, 2024). Together, these developments signal the institutional graduate maturation of smart container subject, marking its transition from experimental innovation to an integral component of global logistics infrastructure.

From an industry perspective Bruno (2022) noted that Hapag-Lloyd's experience illustrated the rapid progression of smart container adoption. This expansion from a few

thousand refrigerated units to 1.6 million standard containers demonstrates how innovations can transform operational activities for all cargo types, referring both to sensitive goods transported within the cold chain and general goods (Bruno, 2022). Therefore, a smart container becomes an operational "normality" and not only a special service for sensitive freight forwarding. Gradually, an increasing share of the world's containers are becoming smart through being equipped with IoT electronics for tracking and monitoring (Levtov & Benmoshe, 2024) but is still lacking in-depth academic research.

In summary, while China holds an unparalleled position in global shipping and container manufacturing, its smart container deployment strategy remains largely domestically contained. By contrast, Western actors started to establish international influence through full container fleet rollouts announcements, claiming the technology leadership. As the smart container model becomes a central component of digital supply chains, the digital influence underscores the tension, which might play a role in the future of maritime logistics. China, by virtue of its scale, remains a critical actor whose technology choices will influence the trajectory of global container digitalisation.

1.6 Scope of the Study

The scope of this study is focused and purposive, concentrating on container level digitalisation in the Chinese context, specifically the adoption, governance and institutional interpretation of track-and-trace technologies applied to dry and refrigerated containers under Chinese ownership or management; from here onwards, track-and-trace technology is used as a synonym for container digitalisation, as it constitutes the first basic layer for rendering containers digitised and therefore 'smart' (Becha et al., 2021).

This synonymy is supported by the fact that track-and-trace serves as the primary use case for smart containers and represents the fundamental translation of logistics asset digitalisation within the maritime sector (Lind et al., 2021; Becha et al., 2021). By transforming a traditionally passive asset into an intelligent node within a cyber-physical logistics network, these technologies enable the real-time visibility and data-driven decision-making central to the Industry 4.0 paradigm (Schwab, 2017; Pessot et al., 2023).

The study examines how organisational actors, regulatory bodies and standardisation institutions understand and operationalise container digitalisation within the wider political economy of Chinese logistics. The inquiry focuses on contemporary developments relevant to the period in which the research was conducted.

The study does not extend to adjacent areas of maritime digitalisation. Port automation, terminal operating systems, vessel level connectivity, maritime cybersecurity, rail-based digitalisation and platform centred trade facilitation are not included except where they provide essential contextual background. The research also excludes technical performance evaluation of specific IoT devices, commercial forecasting of adoption rates or quantitative assessment of market penetration. These domains fall beyond the analytical requirements of the research aim and objectives.

Instead, the subject of analysis is the set of organisational practices, institutional incentives and governance arrangements that shape container digitalisation within China's logistics system. The focus is one analytical generalisation rather than statistical inference. The study, therefore, explains the mechanisms and patterns observed in the Chinese context in a way that might be useful for understanding similar institutional environments, but it does not claim that these findings apply to all countries or all logistics systems.

In summary, this scope delineates the boundaries of the investigation, clarifying the specific topics included and those intentionally excluded. This ensures analytical depth, coherence with the research questions, presented in Chapter Two, section 2.5 and a defensible focus for the empirical and theoretical work that follows.

1.7 Research Challenges

The empirical investigation of container digitalisation in the Chinese context presented several challenges that shaped both the conduct and the limits of the study. These challenges arose from the characteristics of the market, the institutional environment and the nature of the research topic itself.

Empirically, because only a very small proportion of Chinese container fleets currently use track-and-trace technologies, the number of individuals with direct operational or

strategic experience of smart container deployment was limited. This restricted pool of the knowledgeable actors required careful triangulation between interview material, policy texts and industry reports to construct a robust account of practice and expectation. Politically, the sensitivity of topics such as data governance, cross-border data flows and national strategy required a high level of trust and strict adherence to anonymity and confidentiality. Access to Chinese senior decision makers in shipping, manufacturing and standardisation further depended on professional credibility and careful management of the researcher's roles within international bodies.

Additional complexity arose from working across Chinese and English. Most interviews were conducted in Chinese, and their preparation for analysis required transcription and verification in collaboration with a native speaker to ensure fidelity to participants' intended meanings. Although no further linguistic analysis was required, the bilingual nature of the material demanded reflexive attention to how institutional and political concepts are articulated across languages so that coding and interpretation remained accurate. A further analytical challenge stemmed from examining a domain situated at the intersection of technology adoption, regulatory control, industrial policy and international governance. Interpreting the interview evidence required an approach capable of capturing what respondents reported as well as the institutional logics shaping those interpretations.

These challenges reinforced the decision to adopt an interpretivist qualitative research design grounded in semi-structured interviews, bilingual thematic analysis and reflexive quality procedures. These approaches also shaped the scope of the project, which prioritises analytical depth over statistical generalisation. The next section outlines the structure of the study and explains how the subsequent chapters build cumulatively towards addressing the research aim and objectives.

1.8 Specificity and Contribution of the Project

A distinguishing feature of this project is its focus on the digitalisation of the container itself, a subject largely neglected in comparison with the extensive literature on ports, terminals, and vessels (Rochat, 2021; USCC, 2022; PSA International, 2022). While the digital transformation of maritime infrastructure has been documented in relation to

automation, port-community systems, and terminal optimisation (Section 1.5), the container as a digitally enabled asset remains analytically underexplored. This study, therefore, addresses a notable gap by examining the container not merely as a unit of cargo capacity but as a potential data generating node within the wider logistics network. By analysing China's approach, the research contributes to understanding how one of the world's dominant container powers can influence logistics innovation at both industrial and institutional levels.

The project is also distinctive in its empirical access. Collecting qualitative evidence from senior experts in Chinese shipping companies, container manufacturers, and regulatory and standardisation bodies provides insight into a policy and business environment that is often difficult to study directly. As noted in the literature, China's industrial decision-making and data governance structures are not always transparent to external observers (Rosenberg, 2020; Zhang et al., 2025). This study, therefore, contributes original empirical material that enriches an area of research frequently reliant on secondary sources or policy interpretation. The combination of Chinese language interviewing and bilingual coding further enabled the researcher to capture interpretations, conceptual distinctions, and decision rationales embedded in China's institutional and operational context.

The contribution of the research extends beyond empirical access. Conceptually, the project integrates four theoretical domains that are rarely examined together in relation to container digitalisation: developmental state theory, the technology-organisation-environment framework, data-sovereignty and governance debates, and institutional theory. Bringing these perspectives into dialogue allowed the study to illuminate how political ambition, organisational constraints, governance logics, and international legitimacy interact in shaping technology adoption. This integrative approach supports a more nuanced understanding of why digitalisation in China presents both pronounced ambition and uneven implementation.

Methodologically, the study contributes to qualitative logistics research by demonstrating the utility of a bilingual, reflexive thematic analysis for examining technology adoption in politically complex environments. The use of intercoder reliability, analytic notes, and bilingual verification provides a transparent analytical pathway that can be replicated in

future cross-cultural research. By explicitly connecting interview evidence to China's industrial strategy, data security legislation, and standardisation activity, the project shows how micro level reasoning can be systematically interpreted within macro level institutional contexts.

Practically, the research provides insight relevant to shipping lines, technology providers, and policymakers who engage with China in global supply chains. The findings explain why digitalisation outcomes cannot be predicted from technological capability alone but depend on ownership asymmetries, data governance incentives, and state-market relations. These insights offer a foundation for improved collaboration, interoperability planning, and strategic risk assessment within international logistics.

Together, the empirical access, theoretical integration, methodological transparency, and practical relevance give the study a distinctive position within the emerging field of smart container research. The project contributes both substantive knowledge about China's container digitalisation trajectory and a transferable analytical lens for examining similar transformations in other political and institutional contexts.

1.9 Research Rationale

The rationale for this study lies in the need to understand how logistics digitalisation unfolds in a non-Western context where technological ambition, state strategy and commercial pragmatism intersect. China's position as the dominant container nation and a central actor in global trade suggests that its approach to container digitalisation will influence emerging patterns of interoperability, data governance and standardisation. Yet existing academic literature, presented in Chapter Two, concentrates either on Chinese infrastructure initiatives such as ports and terminals or on high level policy documents. These studies offer limited insight into how actors within China interpret and implement container level digitalisation in practice.

This research therefore focuses on the container as a digitally enabled asset and examines how Chinese stakeholders understand and enact track-and-trace technologies within their organisational and institutional environment. The study is motivated by three analytical concerns. Firstly, the study seeks to clarify how smart container technologies are adopted

and evaluated by Chinese organisations and why adoption remains selective even when technological capability is available. Secondly, the project investigates how data generated by these technologies is governed, owned and shared, recognising that questions of sovereignty, security and contractual obligation increasingly structure the digital supply chain. Thirdly, the research explores how governmental stimulation, industrial policy and participation in international standardisation shape the conditions under which smart containerisation develops. Together, these concerns frame the research questions and guide the empirical focus on adoption patterns, data governance and the institutional dynamics influencing digitalisation in China.

1.10 Structure of the Study

This subchapter outlines the overall structure and scope of the thesis. This section explains how the study progresses from contextualising container digitalisation in China, through the development of the theoretical and methodological framework, to the presentation and interpretation of the empirical findings. The intention is to orient the reader to the logic of the research design and to clarify how each chapter contributes to addressing the research aim and objectives introduced in this opening chapter. The structure of this study reflects the progression of a qualitative inquiry that moves from contextual grounding to conceptual framing, methodological justification, empirical investigation, and interpretive synthesis. Each chapter advances the argument by building on the foundations laid before it and prepares the analytical terrain for the chapters that follow.

Chapter One has introduced the context, rationale, and direction of the study. This section established the research problem, explained the strategic and academic significance of focusing on the container as a unit of digitalisation, and defined the overall aim and objectives guiding the investigation. The Chapter also outlined the methodological philosophy and highlighted the practical and analytical challenges of researching digitalisation within China's regulatory, administrative and organisational context. In addition, Chapter One presented the professional and grey literature on China's smart container development to situate the study within contemporary industry discourse and to clarify the commercial and policy context in which the research is positioned.

Chapter Two will set out the current literature and debate. The Chapter examines existing research into global smart container adoption, the conceptual foundations of digitalisation, and China's data governance and industrial policy landscape. The Chapter brought together existing academic research, demonstrating the uneven and fragmented state of knowledge in this domain. In Chapter Two that the research gaps were identified and the research questions were developed. These research gaps and questions informed the theoretical direction and set the agenda for the empirical investigation.

Chapter Three presents the theoretical framework. The focus is on articulation of the four analytical perspectives that anchor the study: developmental state theory, the technology-organisation-environment framework, data governance and sovereignty framework, and institutional theory. Each framework contributed a distinct interpretive lens, and their integration provided the conceptual architecture through which the empirical findings would be examined.

Chapters Four outlines the methodological design, data collection, and analytical procedures. Subchapter 4.2 and 4.3 discussed the research philosophy, epistemological stance, the constructivist logic and the research design underpinning the study. Section 4.4 detailed the sampling strategy and interview process. Subchapter 4.5 explained the data analysis method, including coding procedures, thematic development, intercoder reliability, and reflexive practices as well as the ethical safeguards. Together, these chapters established the transparency, credibility, and analytical rigour required for qualitative inquiry.

Chapter Five presents the empirical findings. Structured around the three research questions, the Chapter examines the dynamics of smart container adoption, data governance practices, and governmental stimulation in the Chinese context. The Chapter distilled the empirical patterns that emerged from the interviews and provided the descriptive foundation upon which later conceptual interpretation is built.

Chapter Six discusses the findings and outcomes of the study through the theoretical framework. This section interpreted the empirical evidence by analysing how state ambition, market pragmatism, and institutional negotiation intersect in China's digitalisation strategy. The Chapter introduced layered hybridity as the conceptual

synthesis of these dynamics, showing how the theoretical perspectives combine to explain the hybrid and often ambivalent patterns observed in practice.

Chapter Seven concludes the study by evaluating how the research aim and objectives were achieved, assessing the quality and limitations of the study, and identifying directions for future research. The Chapter articulates the academic, managerial, and policy contributions of the study and reflects on their implications for understanding global logistics digitalisation in contexts of strategic competition and regulatory diversity.

1.11 Summary and Conclusion of Introduction to the Study

Chapter One has established the foundations of the study by situating container digitalisation within the wider transformation of maritime logistics and by clarifying why China represents a critical context for investigation. The Chapter outlined how the digitalisation of global logistics has increasingly focused on ports, terminals and national infrastructure, while the container itself has remained comparatively underexamined as a digitally enabled asset (1.2). By foregrounding the container as the primary unit of analysis, the Chapter positioned this project within a relatively underdeveloped yet strategically important area of inquiry.

The Chapter then articulated the research problem and business context (1.3), identifying a dual gap. Empirically, there is limited understanding of how Chinese actors adopt, interpret and regulate smart container technologies in practice. Practically, international companies engaging with Chinese partners lack a robust conceptual basis for navigating data governance, interoperability and regulatory expectations at the container level. In response, the overarching research aim was defined as an investigation of China's digitalisation solutions for integrating track-and-trace technology into the global container ecosystem, and four interrelated objectives were formulated to guide the analytical pathway from literature review to empirical analysis and theoretical synthesis (1.4).

To situate this aim in contemporary practice, the Chapter drew on professional and grey literature (1.5) to outline China's market position as a dominant shipping and container

manufacturing nation, and to contrast its relatively modest smart container deployment with the more visible full fleet digitalisation initiatives led by Western logistics actors. This analysis highlighted both China's structural capacity to influence global data flows and the current limitations of its observable smart container rollout, thereby underlining the strategic relevance of the research focus.

The scope of the study (1.6) was then delineated by specifying the organisational practices, institutional dynamics and technological features that fall within the remit of the investigation, and by clarifying which adjacent areas of maritime digitalisation lie outside its boundaries. The Chapter also summarised the theoretical, empirical and practical contributions (1.7) that give the project its distinctive position within emerging smart container research. The rationale and the challenges that shaped the study were subsequently presented. The rationale explained in subchapter 1.8 why a focus on a non-Western, state influenced political economy is necessary for understanding evolving patterns of digital interoperability, data sovereignty and standardisation. The challenges section 1.9 then acknowledged the empirical, linguistic, institutional and political constraints encountered when examining such a sensitive and evolving domain, reinforcing the decision to privilege analytical depth and interpretive explanation over statistical generalisation.

In summary, Chapter One has explained why the digitalisation of containers in the Chinese context matters, what the study seeks to investigate and what kinds of contributions it intends to make. Chapter One has specified the research aim and objectives, clarified the market and policy context and defined the scope and intellectual foundations of the project. The following Chapter Two develops the academic literature review, examining existing research on smart container adoption, Chinese digitalisation and data governance, and identifying the research gaps and questions that frame the subsequent empirical analysis.

2 Literature Review

2.1 Introduction of the Academic Landscape on Container Digitalisation

This Chapter surveys the academic and professional literature relevant to the digitalisation of containerised logistics to establish the conceptual and empirical foundations for the study. The review examines how researchers have approached digital innovation in global logistics, how smart container technologies have been conceptualised, and how institutional, regulatory and geopolitical factors shape their development. Its purpose is to identify what is known, what remains insufficiently theorised and where the literature exhibits gaps that justify the research questions guiding this project.

Throughout this Chapter, Industry 4.0 is treated as the overarching conceptual framework within which digitalisation, IoT-enabled connectivity, data governance, and smart container technologies are situated. Rather than analysing digitalisation and IoT as isolated phenomena, this literature review positions these concepts as constitutive dimensions of the broader Industry 4.0 transformation in maritime logistics. In the context of this study, digitalisation is conceptualised as a core operational aspect of Industry 4.0, reflecting the transition from analogue, document-based processes towards data-driven and interconnected logistics systems.

The Chapter is organised thematically to reflect the principal domains shaping contemporary debates on container digitalisation. The first part outlines the literature search strategy employed to identify English and Chinese academic sources, presented in subsection 2.2. The Chapter then begins its substantive review with a conceptual overview of the Made in China 2025 strategy and the Maritime Silk Road as the China's version of the Industry 4.0 concept in Section 2.3. The Chapter then examines the global smart container adoption (2.4), referring to the conceptual and technological foundations of digitalisation (2.4.1) and the Internet of Things as the key enabler of container tracking

in Section 2.4.1.1, followed by an analysis of Chinese approaches to data governance and legal practice in Section 2.4.1.2. Section 2.4.2 assesses the potential influence of Chinese smart container initiatives on global maritime logistics, identifying how national industrial strategy, organisational incentives and international interoperability shape adoption trajectories. Section 2.5 synthesises the literature to identify conceptual and empirical gaps and establishes research questions guiding this study. Section 2.6, then summarises and concludes Chapter 2 Literature Review, by presenting the academic landscape as to container digitalisation.

Each of these sections establish the conceptual, technological and geopolitical foundations required for understanding China's role in the digital transformation of containerised logistics. The gaps identified in Section 2.5 demonstrate the need for a structured analytical lens capable of addressing the complexity of state driven technological development, data governance and organisational adoption. Chapter Three therefore introduces the theoretical framework that anchors this study, outlining the concepts and models that guide the interpretation of the empirical findings.

The following diagram, Figure 2.1 visualises the conceptual and structural architecture of Chapter Two and demonstrates how the thematic components of the literature review are organised into one framework.



Figure 2.1 Literature Review Chapter Structure

2.2 Literature Search Strategy

The literature reviewed in this Chapter was identified through a structured and iterative search strategy designed to capture both international research on digitalisation in maritime logistics and Chinese academic work relevant to smart container development. Searches were conducted using the University of Gloucestershire's WorldCat Discovery Service for English-language sources, and the China National Knowledge Infrastructure database (CNKI Overseas Edition) for Chinese-language publications. This dual approach ensured coverage of Western theoretical debates alongside Chinese policy, regulatory and technical perspectives that are often absent from international databases.

Search terms were generated to reflect the thematic domains central to this study. Core English-language keywords included "container digitalisation", "smart container", "IoT in container logistics", "container tracking", "real-time supply chain visibility", "digitalisation in maritime logistics", "interoperability in supply chains", "logistics digital transformation", "data governance in logistics", "data sharing in supply chains", "data ownership in logistics", "data sovereignty", "cross-border data governance", "Digital Silk Road", and "Made in China 2025". Additional terms such as "IoT adoption", "regulatory challenges in digital logistics", "platform governance", "logistics standardisation", and "institutional influence on digitalisation" were used when exploring conceptual and regulatory literature.

For Chinese-language sources, equivalent terms were used. These included 集装箱数字化 (container digitalisation), 智能集装箱 (smart container), 物联网集装箱 (IoT containers), 物流数字化 (logistics digitalisation), 数据主权 (data sovereignty), 数据共享 (data sharing), 数据治理 (data governance), 数据产权 (data ownership), 跨境数据流动 (cross-border data flows), 物联网 中国 (IoT in China), 数字丝绸之路 (Digital Silk Road), 中国制造2025 (Made in China 2025), and 智慧物流 (smart logistics). Searches were conducted using both simplified and traditional Chinese characters to ensure comprehensive retrieval.

Three inclusion criteria guided the screening process. Firstly, sources needed to address digitalisation in maritime logistics, containerised transport, or closely related technological domains such as IoT infrastructure, data governance or digital supply chain

management. Secondly, publications were included if they contributed conceptual, empirical or regulatory insights relevant to understanding the evolution of smart container technology. Thirdly, research that addressed China's industrial policy, digital governance frameworks or strategic positioning in logistics was included due to its influence on container digitalisation, even when containers were not the primary focus.

Exclusion criteria were applied to ensure analytical relevance. Studies focusing exclusively on port automation, vessel analytics, general manufacturing digitalisation or blockchain-enabled trade processes were excluded unless they directly informed container-level digitalisation. Commercial press pieces lacking methodological transparency and sources without academic or institutional credibility were also removed or included in the Section 1.5. Backward citation tracking from key publications was used to identify additional relevant works not captured through keyword searches.

This structured search strategy enabled the compilation of a comprehensive body of English and Chinese literature spanning technological, organisational, regulatory and geopolitical perspectives. This approach established the conceptual landscape against which research gaps were identified in Section 2.5 and informed the formulation of the research questions guiding this study. As the study progressed, all sources were systematically rechecked during the finalisation phase to ensure their continued relevance and accuracy, particularly considering evolving regulatory frameworks and technological developments. This final verification step ensured that the evidential base supporting the research remained current, credible and aligned with the empirical and analytical insights presented in the later chapters.

2.3 Made in China 2025 as China's Strategic Interpretation of Industry 4.0

The current phase of global economic transformation is widely conceptualised under the term Industry 4.0, which was originally introduced within the German high technology strategy as a framework for the digital reconfiguration in the manufacturing sector (Schwab, 2017). Industry 4.0 does not denote a single technological innovation but rather a systemic integration of cyber physical systems, advanced automation, real-time data exchange, artificial intelligence and networked production architectures (Pessot et al., 2023). Ghobakhloo et al. (2023) have further emphasised that Industry 4.0 represents a paradigm shift towards intelligent, interconnected and data driven industrial ecosystems in which interoperability, machine to machine communication and cybersecurity become structural preconditions of competitiveness, especially within transport and logistics, as an industry (Pessot et al., 2023). Therefore, Industry 4.0 functions can be used as an umbrella concept encompassing digitalisation, the Internet of Things, big data analytics and platform-based coordination across global supply chains.

Within this broader paradigm, the PRC's *Made in China 2025* initiative can be interpreted as a strategic articulation of Industry 4.0 within the institutional and political context of the Chinese state. Rather than a conventional industrial policy confined to sectoral support, the *Made in China 2025* initiative constitutes a comprehensive programme aimed at restructuring China's position within global manufacturing networks and reducing technological dependence on advanced economies (Guo & Jin, 2018). The initiative aligns closely with the core principles of Industry 4.0, particularly the emphasis on intelligent manufacturing, digital integration and next generation information technologies (State Council of the People's Republic of China, 2015; Ghobakhloo et al., 2023).

The official Notice of the State Council on the Publication of "Made in China 2025" explicitly identifies innovation driven development, the deep integration of information technology and manufacturing, and the upgrading of industrial capabilities as central objectives (State Council of the People's Republic of China, 2015). These priorities mirror the foundational elements of Industry 4.0 as described in the European context, namely the fusion of physical production systems with digital infrastructures and advanced analytics (Schwab, 2017; Ghobakhloo et al., 2023). However, in contrast to the

more decentralised and industry led model associated with Germany's original Industry 4.0 framework, China's approach is characterised by strong central coordination, long term planning mechanisms and explicit geopolitical ambition (Guo&Jin, 2018; State Council of the People's Republic of China, 2015).

Political discourse under Xi Jinping has further embedded industrial digitalisation within broader narratives of national rejuvenation and global governance. Jiang (2015) observes that concepts such as the "China Dream" frame technological advancement as integral to restoring China's historical status and securing strategic autonomy. Peterkova (2020) similarly argues that Chinese policy rhetoric combines references to international innovation norms with assertions of sovereign technological capacity. Within this discursive architecture, *Made in China 2025* functions not only as an economic modernisation programme but also as an instrument of statecraft linking industrial transformation to geopolitical positioning.

The release of *Made in China 2025* on 8 May 2015 formalised this strategic orientation and embedded it within China's broader planning framework, including the Thirteenth Five Year Plan (State Council of the People's Republic of China, 2015). The initiative articulates phased targets extending to 2049, the centenary of the People's Republic of China, thereby situating digital industrial transformation within a long-term horizon of national development. Therefore, *Made in China 2025* can be understood as China's institutional translation of the Industry 4.0 paradigm into a state led model of innovation governance. The MIC25 policy adapts the technological logic of digital integration and intelligent manufacturing to the structural characteristics of China's political economy, combining industrial upgrading, data centric production and strategic autonomy within a unified policy framework.

China's *Made in China 2025*, therefore, can be seen as a strategy, defining a framework for the country's industrial modernisation, particularly in high-technology sectors relevant to maritime logistics and container transportation. This subchapter examines how MIC 2025 seeks to reduce dependency on foreign technology, support domestic innovation, and position China as a global leader in smart manufacturing and digital logistics. The section evaluates the policy's links to smart container adoption, the incentives provided, and its broader geopolitical goals, illustrating how China's state-led initiatives are reshaping global norms for supply chain technologies.

Launched in 2015, MIC 2025 marked a pivotal shift in China's industrial policy, targeting technological self-sufficiency and global leadership in ten strategic sectors, including advanced manufacturing, robotics, and intelligent transport (State Council of the People's Republic of China, 2015). The concept focuses on transforming China from a low-cost manufacturing base into a high-technology industrial powerhouse. Early academic analysis from Wübbeke et al. (2016) noted that China lacked full independence in producing key smart technologies, including sensors and industrial software, which MIC 2025 sought to change. The policy's core ambition was to strengthen Chinese indigenous innovation capacity and support the development of globally competitive domestic companies, often to the detriment of foreign competitors. This included replacing foreign technology providers with domestically produced alternatives across all industrial domains, including logistics. Subsequently, MERICS reported that numerous national funds were established as financial vehicles to drive technological upgrading, surpassing comparative investments in countries such as Germany, which had launched its Industry 4.0 initiative (Lee, 2021b).

Although public references to MIC 2025 declined after 2018 due to geopolitical scrutiny, the policy objectives continue under alternative labels and institutional channels. A recent independent industry report by the Rhodium Group for the U.S. Chamber of Commerce (Boullenois et al., 2025) concluded that the policy remains active through tax incentives and state funding for innovation. Huang Yun, spokesperson and director of the General Office of the State Taxation Administration, reported that approximately 629000 companies benefited from research and development tax deductions, totalling RMB 3.45 trillion, demonstrating strong fiscal support for domestic innovation (Yu, 2024).

In parallel, Government Guidance Funds, state backed public-private investment vehicles, expanded more than five-fold between 2015 and 2020, reaching RMB 11 trillion across more than 1700 funds (Luong et al., 2021). These funds targeted strategic sectors, including semiconductors and artificial intelligence, which are crucial for digitalisation, effectively shifting from direct subsidies to strategic capital allocation (Luong et al., 2021). By 2025, these measures had produced mixed outcomes. With China succeeding in reducing certain import dependencies but by compelling foreign companies to localise production and by accelerating indigenous technological development. Chinese enterprises are predicted to achieve stronger domestic dominance, while foreign

competitors face increasing disadvantages (Wübbeke et al., 2016). Through overseas strategic investments that enable Chinese companies to acquire missing technologies and through restrictions on domestic market access, MIC 2025 has advanced China's telecommunications, semiconductor, and IoT industries (Boullenois et al., 2025).

MIC 2025 emphasised intelligent manufacturing and the integration of enabling technologies such as machine learning, industrial IoT, advanced sensors, and robotics. Inspired partly by Germany's Industry 4.0, the plan envisioned upgrading traditional industries, including shipping and logistics, through smart technologies. In the logistics context, MIC 2025 implicitly supports advances in maritime and rail engineering as well as next-generation information technology essential for real-time container tracking and cargo-condition monitoring (European Union Chamber of Commerce in China, 2025). Although the development of smart container technologies is not explicitly referenced in official MIC 2025 documents, their alignment with MIC 2025's goals of industrial leadership and global competitiveness is evident. The U.S. Chamber of Commerce stated that IoT-enabled logistics is a strategic technology vertical through which China combines state driven innovation with local production requirements to gain an international market advantage (Lee, 2021b; Boullenois et al., 2025). Although sector-specific aims have not been fully met, the general direction of industrial modernisation has been significantly advanced (European Union Chamber of Commerce in China, 2025).

During the MIC 2025 implementation period, Chinese companies including CIMC and COSCO Shipping Line entered the smart container space, developing proprietary IoT solutions such as BoxPlus and CIMC AIoT Technology (BoxPlus, 2025; CIMC, 2024). These developments reflect an ambition for both strategic autonomy and overseas market expansion. China is positioned not only to deploy smart container technologies domestically and along BRI corridors, but also to set international technical standards. In 2023, China unveiled its national smart container standard for refrigerated IoT terminals, implemented in 2025, demonstrating its intention to formalise domestic innovation and promote it internationally (PRC Communication and Transportation, 2025). This standard, reportedly led by COSCO's BoxPlus subsidiary, forms part of China's broader effort to define technical norms for smart logistics (China COSCO Shipping Corporation Limited, 2024).

Parallel analysis by the Mercator Institute for China Studies concluded that rising Chinese IoT penetration, increasing industrial power, and growing data flows create heightened cyber security risks (Lee, 2021b). As more physical assets become internet connected, the global trade system may be exposed to cyber manipulation initiated across interconnected networks (Lee, 2021a). Containers are not only physical assets but mobile ones, which increases the potential vulnerabilities inherent in cyber physical ecosystems controlled by Chinese companies. For MERICS there are concerns about potential Chinese misuse of IoT systems may lead to exclusion from certain digital ecosystems or the formation of geopolitical silos (Lee, 2021b). Such outcomes would undermine both the objectives of MIC 2025 and the core logic of the IoT, which is designed to integrate disconnected physical assets.

From this analysis, *Made in China 2025* has established a coherent policy foundation supporting the development and deployment of smart logistics technologies, including smart containers. Through targeted industrial upgrading, tax incentives, and strategic funding, the policy has contributed to advancements in IT, artificial intelligence, semiconductors, IoT-enabled tracking systems, sensor integration, and intelligent platforms. Although MIC 2025 outcomes vary across sectors, the policy has undeniably strengthened China's position in logistics digitalisation. Chinese companies such as COSCO and CIMC have responded with proprietary systems reflecting both reduced foreign dependency and enhanced international competitiveness. The emergence of national smart container standards further illustrates MIC 2025's intent not only to support domestic industry but also to influence global norms for logistics digitalisation.

While the literature, for example Lee (2021b) and Boullenois et al. (2025) have arguably demonstrated that *Made in China 2025* functions as a central mechanism which is aligned to China's industrial modernisation with its ambitions in digital and smart logistics, however, academic work has not sufficiently examined how MIC 2025 shapes the practical uptake, global positioning, and regulatory trajectory of Chinese smart container technologies. This gap is directly relevant to the present study, which seeks to determine how China's industrial strategy influences the development, deployment, and governance of smart containers at both domestic and international levels. This subsection has demonstrated that China's industrial and logistics strategies frame digitalisation as a central instrument of economic upgrading and geopolitical positioning. Through

initiatives such as *Made in China 2025* and the Belt and Road Initiative, the Chinese state promotes technological self-reliance, infrastructure connectivity and the integration of digital technologies into transport systems. These policies create the institutional conditions for the emergence of smart logistics solutions, including IoT-enabled containers. However, the literature reviewed in this section does not provide clear empirical evidence regarding the scale or operational implementation of such technologies within China's maritime logistics system, because the existing literature remains predominantly policy oriented, macro institutional, and descriptive in focus, rather than grounded in company level, or fleet level empirical observation. Consequently, while strategic intent is well documented, the practical realisation of these ambitions remains insufficiently analysed. The next subsection 2.3.1 reviews the Maritime Silk Road as part of the China's digital strategy and the potential articulation of the *Made in China 2025*.

2.3.1 Maritime Silk Road within China's Digital Industrial Strategy

China arguably plays a critical dual role in global supply chains as both a major exporter and importer (Conte, 2023). With China's rise and the launch of the Belt and Road Initiative (BRI), maritime transportation has been re-envisioned as part of a Chinese-led global supply chain interoperability project (Chen, 2019). The BRI extends beyond traditional trade lanes and encompasses strategic Chinese investments in ports, railways, logistics hubs, digital infrastructure, and economic partnerships. By 2023, close to 150 countries had signed a memorandum of understanding expressing their willingness to participate in the BRI (Wang, 2024). As cooperative development becomes a central indicator of an interconnected global economy, maritime logistics has emerged as a strategic instrument for Chinese power projection (Wei & Ahmed, 2018; Hlongwa, 2020). Wang et al. (2025) explained that in an interdependent global economy, maritime logistics functions based on competition and cooperation. The intensity of logistics interconnection among distant regions has increased significantly in recent years, and up to 80 percent of global cargo volume continues to move by sea (Wang et al., 2025).

Neilson (2012), in outlining five statements on understanding logistics as power, emphasised the relationship between logistics, economics, and statecraft, noting that

maritime logistics today produces new forms of influence through automation and digitalisation. Wei and Liefner (2012) concluded that China has become a critical force in accelerating globalisation, with rapid growth and structural transformation driven by extensive foreign direct investment and international trade. As explained by Wei and Ahmed (2018) and Hlongwa (2020), this model has spilled over into Chinese geopolitical strategy, where logistics infrastructure is designed not only for trade facilitation but also for normative influence over global supply chain technologies. Digitalisation, highlighted by Neilson (2012), is institutionalised in the Digital Silk Road, which extends digital infrastructure across BRI hubs (Al Shaher et al., 2023). The Digital Silk Road focuses on the deployment of artificial intelligence, 5G networks, Big Data, and the Internet of Things, aiming to advance China's export capacity and geopolitical influence through what has been described as high-technology and digital diplomacy (Sahakyan & Parzyan, 2024). As part of this initiative, new telecommunications infrastructure, including fibre-optic networks and the export of Chinese digital technologies, increases IoT interoperability across BRI regions (Sahakyan & Parzyan, 2024).

China's trade routes are integral to both the BRI and the *Made in China 2025* vision of digitalisation and industrial modernisation (Levtov, 2020). Intermodal container transportation combining land and sea, particularly the rail corridors to Europe, has gained increased importance as volumes surged prior to the COVID-19 pandemic and the Russia-Ukraine conflict (Zhang et al., 2025; Sahakyan & Parzan, 2024). To enhance efficiency and reduce costs along these corridors, Chinese discourse advocates for advanced planning systems and automation technologies. In this optimisation process, shipping lines play a central role, acting as both freight forwarders and contract administrators between cargo owners, agents, and other participants in multimodal transport (Wang et al., 2025). Collaborations occur between port infrastructure providers and carriers, as illustrated by OOCL and COSCO partnering with the Shanghai International Port to secure efficient operations for large vessels and container flows (Wang et al., 2025). Such cooperation also signals intensified competition among global shipping alliances. When embedded within the BRI or Maritime Silk Road, these partnerships reflect long-term planning and ambitions for global maritime influence.

The Maritime Silk Road (MRS) spans regions including sub-Saharan Africa, Oceania, and South America (Yao & Hu, 2018), demonstrating China's global reach.

Comprehensive state involvement in MSR development, coordinated with local modernisation agendas in partner countries, has significant implications for global trade and geopolitics (Yao & Hu, 2018). Together with the land corridors of the Belt and Road Initiative, the Maritime Silk Road links over sixty countries across four continents, establishing an unprecedented scope of influence (Su, 2018).

However, not all assessments are positive, for example with Manners-Bell (2023) who argued that rising geopolitical tensions increasingly undermine the economic rationale of long supply chains. Supporting this Manners-Bell (2023) contended that the use of transport and logistics as instruments of political influence or security leverage increases uncertainty and cost, particularly for Western businesses and consumers. Ongoing geopolitical conflicts and strategic decoupling contribute to the geographic redistribution of manufacturing, especially high-technology components, from West to East, altering global economic balances (Manners-Bell, 2023). Nevertheless, despite growing geopolitical constraints, supply chains remain foundational to the functioning of the global economy, sustaining the movement of goods and the interdependence of markets.

Within the Maritime Silk Road context, Industry 4.0 tools, such as IoT and related digital technologies serve as force multipliers. IoT devices embedded in ship engines, onboard systems, and port equipment contribute to the emerging Internet of Ships and Sea Services, a term describing the extension of IoT throughout maritime operations (Lambrou et al., 2019). This technological upgrade enhances visibility and automation throughout end-to-end supply chains. The integration of artificial intelligence and blockchain alongside IoT further enables predictive analytics, condition monitoring, and decentralised, secure data exchange, all of which underpin the evolving Digital Silk Road. Such technologies provide more than operational transparency, whereby offering predictive capabilities for maintenance, risk assessment, and disruption mitigation (Lambrou et al., 2019). Therefore, digitalisation technologies can transform the Maritime Silk Road from a physical transport network into a digitally integrated logistics ecosystem capable of coordinating, optimising and securing flows across the entire maritime supply chain.

Maritime container logistics are directly shaped by the technological capabilities deployed by major carriers and stakeholders, many of which are Chinese or linked to BRI

investments. Container supply chains involve multiple phases and frequent transitions across modes, from contracting and rate negotiation to multimodal transport, customs clearance, and final delivery (Song, 2021). Synchronisation and transparency are critical across these phases (Song, 2021). Ports and terminals serve as essential interfaces between sea and inland transport, yet they often face congestion and planning challenges. China's BRI port investments combine physical infrastructure with smart technologies and digital logistics platforms, enhancing not only port efficiency but also positioning these hubs as nodes within a broader architecture of smart, data-enabled supply chains. However, although outward investments along the Maritime Silk Road contribute to international connectivity, their impact on domestic industrial upgrading is more limited. As Su (2018), and Yao and Hu (2018) argued that China's domestic industrial transformation drives overseas investments more than these investments reshape the domestic landscape.

Despite these strategic ambitions, there is no clear evidence suggests that Chinese-owned containers have been digitised at scale or deployed as interoperable smart assets across rail, sea, and road networks. Rail freight, part of the overland Silk Road, continues to face longstanding infrastructural challenges such as incompatible track gauges that cause delays and resist modernisation (Hilton, 2023). These structural issues illustrate why maritime, and rail logistics often fall behind other sectors in digital adoption and underscore the necessity of focused digital initiatives such as smart containers, which could provide real-time reporting on delays or damage across multimodal transport.

In conclusion, the Maritime Silk Road and Digital Silk Road illustrate how China fuses physical infrastructure with digitalisation to shape global trade corridors. This state-driven model integrates smart port systems, connected logistics platforms, and IoT-enabled capabilities within a broader geopolitical strategy and demonstrates the application of the MIC25 ambition within the supply chain industry. However, the academic literature does not sufficiently examine how these outward looking initiatives relate to China's asset level digitalisation, as well as does not refer to the domestic regulatory environment, and data governance structures. Crucially, there is limited analysis of whether China's external digital ambitions are supported or constrained by its internal legal frameworks, institutional priorities, and governance mechanisms. These omissions are directly relevant to the present study, since any international deployment

of smart container technologies depends on the domestic conditions that govern their development, data handling, and operational acceptance. The next subsection reviews the global smart container adoption within the concept of the Industry 4.0 and its conceptual and technological foundations, such as IoT, data governance and handling, searching to evaluate the potential influence of the Chinese smart container adoption.

2.4 Global Smart Container Adoption

Despite increasing academic and industry attention to digital innovation in global logistics, research on the diffusion, governance, and strategic implications of smart container technology remains fragmented and underdeveloped (Ivanov, 2021; Raza et al., 2023). The digital transformation of maritime logistics has the potential to reshape how supply chain related activities operate and interact across jurisdictions (Lind et al., 2021). One of the principal drivers of this shift is the advancement of track-and-trace technology, as a translation of the logistics assets digitalisation and the growing interest in smart container deployment (Becha et al., 2021). Containerised trade continues to frame international commerce, and recent developments in the Internet of Things, artificial intelligence, and blockchain have encouraged the pursuit of real time visibility, automation, and enhanced operational resilience (UN ECE, 2019; Yuen et al., 2019). Yet adoption remains inconsistent, especially for container level tracking and condition monitoring, with organisational, regulatory, and interoperability constraints repeatedly cited as barriers (Raza et al., 2023; Manners-Bell, 2023).

China has emerged as a central actor in this transformation. National initiatives such as *Made in China 2025* (Wübbeke et al., 2016) and the Belt and Road Initiative (Hlongwa, 2020) illustrate the role of industrial policy and infrastructural investment in shaping China's contribution to digital logistics. These programmes position digitalisation as a strategic national priority and frame China's ambition to influence global supply chain norms through both physical and digital infrastructure.

Smart containers represent a sector-specific manifestation of Industry 4.0 in maritime logistics, where IoT-enabled hardware, embedded sensors, and data platforms converge to transform a traditionally passive asset into an intelligent node within a cyber-physical logistics network. To understand how global smart container IoT technology has been

influenced by China's smart container strategy, it is essential to outline the historical trajectory and evolving role of maritime logistics in global trade. Maritime logistics has long been the backbone of international commerce, and its foundational role is increasingly shaped by digitalisation (Lind et al., 2021). The historical significance of maritime transportation can be traced back to ancient trade routes such as the Silk Road, which continue to underpin East-West connectivity, although contemporary flows rely predominantly on container shipping as the primary mode of international cargo movement. Before the formal establishment of the Silk Road during the Han Dynasty, trade already flourished along East-West routes, with merchants and nomadic groups exchanging goods, technologies, and cultural practices across vast territories (Hansen, 2012). This early commercial activity laid the foundations for today's complex global logistics systems and the formation of the Maritime Silk Road and illustrates the long-term importance of East-West trade corridors.

The evolution of maritime logistics accelerated during the Industrial Revolution, when advancements in steamship technology, port infrastructure, and global trade networks reshaped how goods were transported. The nineteenth and early twentieth centuries witnessed the rise of imperial shipping routes, later replaced by post-war supply chains that contributed to the globalisation of trade and production (Headrick, 2010; Levinson, 2016). Levinson (2016) contended that a decisive event occurred in 1956 when Malcolm McLean launched the first container ship, initiating the standardisation of cargo handling through the Twenty Foot Equivalent Unit (TEU). This innovation catalysed containerisation and dramatically reduced port congestion, theft, and labour costs.

This historical backdrop underscores the embeddedness of maritime logistics within broader global trade transformations and illustrates how the sector has continually adapted to technological change. Since 1956, maritime logistics has undergone further structural shifts with the emergence of digitalisation, the rising importance of smart container technologies, and the development of container IoT track-and-trace systems, each introducing new challenges and opportunities (Becha et al., 2021). Containerisation facilitated the exploitation of peripheral production zones by enabling rapid, low-cost transport of goods to major consumption hubs. The global value chain framework conceptualises how container standardisation supports the modularisation of production, with components sourced from multiple regions and assembled in strategically chosen

locations (Gereffi & Fernandez-Stark, 2016). Locations such as the Port of Rotterdam became global logistics hubs through early investments in container terminals, while the development of mega-ports in East Asia, including Shanghai and Singapore, demonstrates how containerisation reshaped urban development and global economic hierarchies (Notteboom & Rodrigue, 2005).

Aligned with global value chain evolution has been the adoption of lean logistics, which emphasises the reduction of safety stock across supply chains (Lam & Zhang, 2014). Shipping lines have demonstrated improvements in schedule reliability to support just-in-time inventory practices (Zhang & Lam, 2014). These developments reiterate the importance of interoperability among supply chain stakeholders, such as logistics service providers and ports. Traceability of container movements and coordinated information flows enable faster decision-making and strengthen supply chain integration (Yuen et al., 2019).

Cold-chain logistics provides a concrete illustration of the dependence on technological monitoring. If a refrigerated container loses power or experiences refrigeration system failure during transit, cargo quality can rapidly deteriorate. Temperature control remains a persistent challenge, and as Nie et al. (2019) highlight, bottlenecks include inadequate temperature monitoring technologies, fragmented data systems, and limited early-warning mechanisms. Modern IoT-based solutions offer real-time updates and alerts for temperature excursions, helping to address longstanding operational vulnerabilities (Nie et al., 2019). These examples collectively demonstrate that deeper supply chain integration depends increasingly on digitalisation.

Building on this conceptual foundation, the ongoing digitalisation of maritime logistics signals a continuation of global structural change, where emerging technologies shape infrastructure, organisational practices, and market expectations (Ceyhun, 2020). Maritime logistics remains central to international supply chains, with approximately eighty percent of global trade by volume carried by sea due to low freight rates, flexible routing, and the capacity to transport large volumes (Chen, 2019). Digitalisation enhances these advantages. The development of digitising technologies has encouraged some container owners and operators to adopt smart containers equipped with IoT sensors and artificial intelligence to support continuous monitoring (UN ECE, 2019). Smart containers now provide stakeholders with real-time data on location, environmental

conditions, maintenance status, and cargo parameters (UN ECE/UN CEFACT, 2019). The convergence of physical and digital infrastructure signals a broader transformation in which maritime logistics evolves from a transportation function to a more integrated, data-driven ecosystem capable of proactive, rather than reactive, management. As UN ECE/UN CEFACT Smart container Business Requirements Specification claims, real-time data enables operational visibility and decision-making during transit, which is essential for contemporary supply chain performance (UN ECE/UN CEFACT, 2019).

This historical and technological evolution shows that maritime logistics has experienced major transitions, culminating in the current wave of digital innovation. The shift toward smart container technologies marks a movement beyond simple conveyance of goods toward integrated logistics systems driven by data connectivity. Understanding this global transformation is foundational for analysing how such technological developments have been adopted and shaped by Chinese container owners.

Despite the clear historical progression from containerisation to digital integration, current literature review provides only a partial understanding of how smart container technologies are being adopted globally. Much of the existing literature, for example Raza et al. (2023), Ivanov (2021), Cortes-Murcia et al. (2022), Herold et al. (2021) focus on technological functionality, operational optimisation, or discrete sectoral applications, yet offers limited engagement with the strategic, institutional and geopolitical conditions that shape adoption trajectories. There is little examination of how national industrial priorities influence technology diffusion or how disparities in digital capability among container owners affect global interoperability. These omissions are most visible in relation to China, where descriptive accounts of logistics development dominate, while systematic analysis of state driven technological ambition and its implications for global governance remains scarce.

Addressing these gaps requires deeper conceptual grounding in the technological and organisational bases of digitalisation. The next subsection therefore elaborates the conceptual and technological foundations that frame smart container systems and provides the analytical base necessary to assess China’s emerging role in this domain.

2.4.1 Conceptual and Technological Foundations of Digitalisation

Following the historical background of maritime logistics, it is essential to present the current digitalisation efforts within established conceptual and technological frameworks. This subsection examines the academic and technological foundations that frame the digitalisation of logistics and supply chain operations, focusing on the conceptual distinction between digitisation and digitalisation, the broader transformations associated with the Fourth Industrial Revolution, and the way these developments have manifested within maritime logistics. Particular attention is given to how digital tools and platforms have enabled end-to-end visibility, process efficiency, and sustainability across an industry that has traditionally been conservative in adopting technological innovation.

Growing interest in end-to-end visibility has accelerated digitalisation efforts in maritime logistics. It is, therefore, critical to clarify the distinction between digitisation and digitalisation, as these terms are often applied interchangeably. Digitisation refers to the creation of digital representations of physical objects and attributes (Gong & Ribiere, 2021), whereas digitalisation involves the use of digital technologies and digitised information to reshape socio-technical structures (Osmundsen et al., 2018). Digitalisation builds upon digitisation to increase process efficiency, reduce costs, and improve profitability (Raza et al., 2023). Clarifying these conceptual differences is important for assessing how Chinese logistics actors interpret and adopt global digitalisation narratives, and for determining whether their approach to smart container deployment aligns with or diverges from international trajectories in track-and-trace innovation.

Despite widespread business adoption of digitalisation in existing supply chains, academic research on real-time cargo container tracking remains limited (Ivanov, 2021; Cortes-Murcia et al., 2022; Herold et al., 2021; Raza et al., 2023). Existing academic debate on IoT track-and-trace technology in global container transportation, such as Raza et al. (2023), indicates that this domain is still in its infancy. This points to a persistent gap between industry practice and academic knowledge. The notion of the Fourth Industrial Revolution has been characterised by automation and data exchange across technologies, promoting digitalisation in industry and introducing tools that support higher efficiency and sustainability within supply chains (Schwab, 2017). Some of the United Nations Sustainable Development Goals (SDGs) can be advanced through

digitalisation (Cortes-Murcia et al., 2022), particularly those encouraging high-technology logistics ecosystems that facilitate cooperation and interoperability within volatile political and market environments. The alignment with the SDGs reinforces the argument that digitalisation is not a transient trend, but a long-term structural development.

From a technical standpoint, supply chain digitalisation involves implementing hardware and software systems that replace manual data collection with digital solutions. This transformation has improved business and societal outcomes by increasing efficiency and competitiveness (Bumann & Peter, 2019). One of the key outcomes has been the creation of end-to-end visibility, conceptualised by Ivanov (2021) as a digital twin of the physical supply chain. In this model, all relevant data are collected, processed, and updated in real time, allowing for a virtual replica of physical operations. The replication of the physical world in cyberspace necessitates robust governance frameworks for data security and safety. These critical issues are examined further in Chapter Three subsection 3.4.

Although the conceptual and technical literature highlights the benefits of digitalisation (Ivanov, 2021; Bumann & Peter, 2019), real-world implementation across logistics modes continues to face structural and institutional barriers. Transport and logistics are among the oldest human activities, and many traditional sectors maintain deeply embedded practices. Digitalisation has transformed several transport sectors, yet maritime and rail logistics show slower uptake relative to air and road freight (OECD/International Transport Forum, 2019). The disruptions associated with the Fourth Industrial Revolution, globalisation pressures, lean management approaches, and the shocks of the COVID-19 pandemic have challenged even these conservative modes (Ivanov, 2021). Hilton (2023) observed that maritime and rail freight forwarding continues to rely on century-old infrastructure decisions, creating delays and inefficiencies. Raza et al. (2023) concluded that the liner shipping segment of the maritime sector remains significantly behind other modes in embracing digitalisation. Often family controlled and network centric, with up to forty separate actors involved in a single voyage, maritime logistics suffers from low transparency, costly manual processes, high fuel prices, and increasingly stringent environmental regulations (Raza et al., 2023). Digitalisation could theoretically generate greater transparency and efficiency, yet the composite nature of maritime logistics creates a bottleneck for technological

adoption. A single shipment may involve multiple transportation modes and a web of partnerships among shipping lines, rail operators, trucking companies, ports, and terminals, each requiring separate integration and technological alignment. This complexity may partly explain the slow adoption of smart containers.

Organisational theorists have argued that the spread of digitalisation depends on institutional discourse and collective narratives (Herold et al., 2021). In this regard, digitalisation can be understood as a social construct, where companies adopt technologies at different intervals based on shared perceptions of potential benefits. Widespread technological advancement may only occur when the entire supply chain ecosystem, rather than isolated actors, recognises the necessity of digital dependency and the limitations of manual processes. Current literature, including Manners-Bell (2023), has identified a lack of common digitalisation strategies, insufficient technical capabilities, high implementation costs, limited standardisation, cyber security risks, and interoperability failures as obstacles that hinder technology diffusion (Pagano et al., 2022; Egloff et al., 2018; Gunasekaran et al., 2017; Mathauer & Hofmann, 2019; Tijan et al., 2021). For Kuo et al. (2022), key drivers of digital transformation in maritime logistics include shifting customer requirements, cost reduction pressures, new legislation, and heightened competitive dynamics (Kuo et al., 2022; Sullivan et al., 2020; Tijan et al., 2021). Herold et al. (2021) further suggested that client-driven expectations and competitive pressures have influenced the recent discourse favouring digitalisation. From this perspective, the adoption of smart container technologies may be accelerated through customer-led initiatives. However, the relationship between the demand for smart container services and their availability might demonstrate a bidirectional dependency, as limited supply restricts demand growth. This interdependency represents an additional challenge for the adoption of smart container technologies.

In summary, the literature on digitalisation in maritime logistics is neither consistent nor cohesive. While conceptual and technological frameworks indicate significant potential benefits, including efficiency gains, visibility improvements, and competitive advantage, real-world implementation remains fragmented. Legacy systems, organisational inertia, and the absence of harmonised approaches impede progress. The literature suggests that container digitalisation is challenged by the complexity of supply chain environments, low customer demand, and uncertainty arising from persistent digital data traces. This

debate highlights both the promise and the limitations of existing technological capabilities.

Despite these insights, the academic literature offers only limited conceptualisation of how digitalisation frameworks apply specifically to container-level technologies. Existing studies rarely examine container digitalisation as a distinct phenomenon, lacking the integration of technological, organisational, and institutional dimensions into a unified analytical model. Furthermore, the literature does not adequately explain how national strategic approaches, such as those emerging in China, interact with global digitalisation narratives or shape the technological direction of supply chain digitalisation. These gaps illustrate the need for a more targeted examination of how conceptual and technological foundations intersect in the context of smart containers. The following section therefore examines the Internet of Things as the core enabling technology for container digitalisation, providing the technical basis for understanding China's approach to smart container deployment.

2.4.1.1 Internet of Things in Container Tracking

Given the fragmented adoption of digital solutions in maritime logistics, the Internet of Things has become a fundamental technology for the digitalisation of global logistics, particularly in relation to container transportation. Within the Industry 4.0 paradigm, the Internet of Things functions as the technological backbone that enables real-time data generation, asset visibility, and machine-to-machine communication in global supply chains. This section introduces the core structure of IoT networks and examines how these systems are deployed within maritime freight. Subchapter 2.4.1.1 reviews the layered architecture of IoT infrastructure, the differences between active and passive tracking hardware, and how these systems enable real-time cargo visibility and data-driven decision making. To contextualise the discussion, commercial examples and academic perspectives are presented to evaluate the efficiency, cost-saving potential, and risk reduction capabilities associated with IoT in container shipping.

IoT technology has disrupted traditional supply chain management. Central to digital initiatives in transport and logistics is the infrastructure for data harvesting, storage, processing, and sharing (Raza et al., 2023). Kevin Ashton first used the term Internet of Things in 1999 to describe a network of physical objects digitally interconnected to sense,

monitor, and track information, thereby enabling visibility and information sharing within and between organisations (Birkel & Hartmann, 2020). IoT systems are typically structured into four layers. Firstly, the sensing layer harvests data from the physical world via sensors. Secondly, the networking layer transfers data across wired or wireless networks. Thirdly, the service layer integrates and manages services and applications. Fourthly, the interface layer presents data in a user-friendly format (Birkel & Hartmann, 2020).

The main purpose of IoT applications in logistics is remote consignment management and cargo condition monitoring. Key parameters tracked include location, temperature, humidity, estimated time of arrival, and indicators of potential damage (Yu et al., 2022). In maritime logistics, IoT addresses challenges arising from fragmented networks, varying time zones, and global operational complexity by providing real-time location tracking. Such visibility enables significant cost benefits by revealing operational patterns, identifying bottlenecks, and enabling more agile responses to disruptions (Raza et al., 2023). IoT not only enhances operational efficiency but also reduces waste and enables proactive risk management (Yu et al., 2022). By providing timely alerts and rich data streams, IoT supports informed decision making for longer term risk prevention, while improving overall supply chain performance, reducing resource wastage, and increasing asset utilisation.

IoT sensing hardware is generally categorised as either active or passive. Active devices contain internal power sources and therefore transmit data autonomously at predefined intervals or in response to specific events. Passive technologies, exemplified by Radio Frequency Identification (RFID) tags, contain little or no on-board power and must be activated by external readers to capture and relay data (Yan et al., 2018). The academic literature has predominantly concentrated on passive technologies such as barcodes and RFID, largely because of their low cost and established operational roles. In contrast, active tracking devices have gained commercial traction in logistics but remain comparatively under examined. Their capacity for immediate data transmission makes them considerably more appropriate for real time condition monitoring and positional tracking in long haul multimodal shipments.

Smart containers rely on a structured multi-layer IoT architecture that supports continuous sensing, communication and decision support across the logistics chain. Four

layers are typically distinguished. The sensing layer includes embedded instruments that record variables such as temperature, humidity, shock and door status. The network layer conveys these data via cellular, satellite or low power wide area technologies including NB IoT, LPWAN and LoRaWAN. The service layer undertakes data aggregation, event detection and integration with enterprise logistics systems. The application layer provides end users with dashboards, alerts or analytical tools to support operational decision making (Birkel & Hartmann, 2020, Song et al., 2021).

These technologies are particularly prevalent in cold-chain logistics, where temperature-sensitive goods require continuous monitoring across different carriers and geographies. For refrigerated containers, continuous monitoring is critical regardless of whether the container is on a vessel, truck, or train. Active IoT sensors can ensure that temperature remains within acceptable thresholds throughout transit (Ben-Daya et al., 2021). Service and interface layers have also benefited from the application of blockchain and artificial intelligence, which can enhance data integrity and trust in multimodal environments (Kumar et al., 2022).

To illustrate the concept of the cold chain, if a sensor detects a temperature deviation beyond a defined threshold, the service layer can generate an immediate alert that enables corrective intervention during transit, for example by adjusting the container's power supply or rerouting this CTU to a nearby facility (Li & Li, 2020; Dong et al., 2024). Low power wide area communication protocols such as NB-IoT have been increasingly adopted due to their low energy consumption and deep signal penetration, which is advantageous in port environments and remote areas that lack full 4G or 5G coverage (Li & Li, 2020; Dong et al., 2024; Quectel, 2024). A cost-effective performance of the IoT technology might reduce price for the hardware and data transfer services and service-quality barriers to digitalisation adoption. As IoT becomes the technological foundation for container digitalisation, it could set functional expectations and technical standards that would influence how the global logistics sector conceptualises smart container deployment and creates reference points that could shape both national and commercial strategies. Since IoT encompasses both hardware and software dimensions, this research examines questions related to hardware technology origin and the data governance frameworks that underpin software capabilities in IoT-enabled smart containers.

In summary, IoT plays a transformative role in the evolution of container logistics by enabling greater visibility, efficiency, and safety. As maritime supply chains become increasingly digitised, IoT integration enables more accurate tracking and monitoring of containers, providing real-time data for informed decision making. However, the rapid commercial adoption of IoT has outpaced academic analysis. Current literature review provides limited examination of how IoT solutions influence broader issues such as data governance, security, interoperability, and standardisation. Part of the challenge relates to the speed of technological development. Commercial deployment of IoT-enabled smart containers is advancing global expectations for real-time supply-chain visibility, as mentioned in Section 1.5 and establishing functional benchmarks that shape the conditions under which industry actors operate. Another challenge concerns the power and value of the data collected, including questions related to data administration, cross-border data flows, and potential risks arising from fully digitised container fleets.

Despite the clear technical foundations and rising commercial reliance on IoT for container tracking, the academic literature provides only partial and fragmented analysis of how container digitalisation operates in practice. Although historical and conceptual studies emphasise the transformative potential of containerisation and digitalisation (Lind et al., 2021; Levinson, 2016; Gereffi & Fernandez-Stark, 2016), there remains an absence of detailed academic evaluation of real-world smart container deployments, including those undertaken by major carriers such as Hapag Lloyd, Maersk, and ZIM, mentioned in Section 1.5. These case studies appear in grey professional literature but have not been examined systematically within academic research, leaving an unresolved gap between documented industry practice and academic understanding. The literature also highlights a lack of common digitalisation strategies and persistent structural obstacles, including low customer demand, the absence of standardisation, cyber security risks, and limited cooperation across fragmented logistics networks (Manners-Bell, 2023; Pagano et al., 2022; Egloff et al., 2018; Gunasekaran et al., 2017). While IoT enabled refrigerated containers dominate the sector due to relatively straightforward technical integration, the spillover effect into non-powered dry containers remains inconsistent, with no reliable forecast of broad fleet-level adoption (Li & Li, 2020). This uneven diffusion reflects not only technological challenges, but also institutional and market level uncertainties. IoT has enabled smart containers to generate continuous streams of operational and environmental data, yet the governance, control, and long-term handling of these

persistent data traces remain insufficiently examined in current research. Together, these gaps demonstrate that while global discourse supports the digital transformation of maritime logistics, widespread implementation of smart container technologies is challenged by technical, organisational, and institutional complexities. This gap underscores the need for a deeper analysis of data governance practices, legal frameworks, and national strategies, particularly in the context of China's emerging leadership in smart container development. The next subsection therefore examines approaches to data handling and the Chinese legal specificities that shape the deployment and governance of digitally enabled container technologies.

2.4.1.2 Approach to Data Handling and Chinese Specifics

The integration of smart containers into global logistics brings questions of data ownership, interoperability, and governance to the forefront of supply chain digitalisation. As containers move across jurisdictions and interact with diverse digital systems, issues arise concerning harvested data ownership, data access, data sharing, and the legal frameworks that regulate these processes. From an Industry 4.0 perspective, data governance constitutes the regulatory and institutional layer that shapes how digitally generated supply chain data are owned, shared, and controlled across jurisdictions (Ghobakhloo et al., 2023). This subsection examines the governance mechanisms that shape container data handling, focusing on institutional access, stakeholder transparency, and real-time data exchange across international networks. The subchapter also compares international and Chinese legal frameworks to identify similarities and differences in how data ownership rights and sharing principles are defined and enforced.

Abbas et al. (2024) defined the data sharing as a "process, irrespective of domains, where businesses, for example data providers, who offer other businesses, like data consumers access to their data. Data consumers utilise these data to develop new applications and services. In return, data providers expect rewards, either monetary or other incentives, such as reciprocal data sharing" (Abbas et al., 2024, p.1). In their discussion of data ownership, Abbas et al. (2024) emphasised that data ownership and privacy rights form baseline entitlements held by data providers and data subjects. These rights exist as preconditions before any data - sharing transaction occurs (Abbas et al., 2024, p.17).

Data sovereignty is a foundational requirement for data sharing (Scheider et al., 2023; Schweihof et al., 2023) because it allows data providers to retain control over how their data are used and accessed (Hellmeier & von Scherenberg, 2023). Data sovereignty is central to an organisation's willingness to participate in data - sharing arrangements (Opriel et al., 2021). The concept highlights that the entity collecting or commissioning the data maintains authority over its use and distribution, typically enforced through contractual agreements. For example, the European Commission's Data Governance Act establishes frameworks aimed at facilitating data sharing while safeguarding individual and organisational rights (European Commission, 2022b). Data governance provides the organisational and managerial structures required to handle data effectively (Abbas et al., 2024; Vatanparast, 2020). Within supply chain networks, data handling principles are often defined through consortium agreements among business partners, which makes the establishment of international governance mechanisms, shared technical standards, and joint regulatory practices more complex (Gelhaar & Otto, 2020).

From a business perspective, data handling in the context of smart containers is often contested due to overlapping jurisdictions, differing technical capabilities, and divergent regulatory environments. Data ownership is frequently determined through contractual agreements, where the entity that funds or commissions data collection asserts ownership through clearly defined terms (Offor, 2020). In many industrial settings, the organisation that generates or collects operational data is treated as its primary owner or sovereign controller (Lis & Otto, 2020). This logic extends to supply chain digitalisation, where asset owners commonly assert rights over the data produced by their equipment. Leading industry frameworks such as the International Data Spaces Reference Architecture confirm that the entity providing or generating the data retains the underlying rights to determine access, reuse and sharing conditions (International Data Spaces Association, 2019; Pettenpohl et al., 2022). Such agreements specify the roles, responsibilities, and rights of the parties' exchanging data, including usage conditions and restrictions, thereby enabling the paying entity to maintain control over subsequent data usage (O'Hara, 2020).

In China, approaches to data ownership and sharing differ significantly because they reflect the state's focus on national control and security. Although Chinese law does not explicitly assign data ownership to the paying entity, contractual arrangements remain central in defining usage rights. Parties are encouraged to specify how data may be

handled, processed, and shared (DLA Piper, 2025). However, these private arrangements operate under the overarching authority of Chinese national laws, which assert the state's sovereign interests. Compared with the European Union, the Chinese legal framework emphasises a more interventionist governmental role in digital privacy and data management (Zhang, 2024). The Personal Information Protection Law emphasises individual consent and rights over personal data, requiring organisations to obtain explicit consent for collection and processing (The National People's Congress of the People's Republic of China, 2021). Within the context of smart containers, personal information such as container operator details, agent identities, or customer information may, in practice, be accessible to the state.

However, the Data Security Law imposes restrictions on transferring data overseas (Article 31) and grants the state broad authority to access and collect data for national-security purposes (Article 35), including prohibiting organisations in China from providing data to foreign authorities without Chinese government approval (Data Security Law, 2021). The Cybersecurity Law mandates data localisation and security protocols for network operators (Cyberspace Administration of China, 2017). Zhang (2024, p. 11) concluded that China adopts a centralised approach, characterised by stricter data-localisation requirements and stringent regulation of cross-border data flows. These laws ensure that data handling aligns with national security and public interest and effectively limit the degree to which private contracts can confer full data control rights to commercial actors, especially foreign entities.

In contrast, Western regulatory regimes such as the EU's General Data Protection Regulation and the California Consumer Privacy Act prioritise personal data protection and define the responsibilities of data controllers while granting certain privileges to data-collecting entities (European Parliament and Council of the European Union, 2016; Bonta, 2024). Nevertheless, China's Personal Information Protection Law, Data Security Law, and related measures emphasise that both personal and industrial data must be processed in ways that do not compromise national interests. These differences are highly relevant for logistics and container data, which may include location data of strategic shipments or metadata that governments consider sensitive. Academic research has not yet adequately explored these implications, which this study intends to address.

The Data Property Rights System introduced in 2022 regulates both personal and non-personal data and sets obligations for data handlers, defined as entities that collect, process, and store data (Huang, 2024). This system suggests that China may increase market access for foreign digital service providers only if they comply with data-localisation requirements. Non-Chinese IoT providers may potentially offer their services to Chinese shipping lines, but only under operational conditions such as domestic localisation of computing facilities.

China's approach to IoT data security has undergone decisive regulatory and institutional change. In 2024, the government promulgated new "Network Data Security Management Regulations," effective 2025, raising compliance obligations for data handling and security across industries, including IoT (Interesse, 2024). China's dominance in electronics manufacturing and the use of Chinese infrastructure for cellular connectivity reinforce China's presence in global IoT ecosystems, regardless of where IoT devices are assembled (Lee, 2021b). Key milestones include the Ministry of Industry and Information Technology's release of IoT security standards, which outline systemic risks and propose a multi-level security framework (MIIT, 2021). By 2022, China aimed to establish a basic IoT security standard system, and by 2025 the goal was to develop a comprehensive suite of industry standards to enhance security across IoT applications (MIIT, 2021). As of July 2025, a call for experts to participate in drafting these standards had been issued, although official publication remained pending (CESI, 2025). Once published, it will be important to assess whether these standards support smart container adoption in China and whether they enable China to influence global smart container technology markets.

Companies operating large data services may challenge governmental control as data volumes grow (Zhang, 2024). High-profile interventions involving companies such as Didi (Borak, 2021) and Alipay (Bloomberg News, 2023) indicate that the Chinese government may intervene when private sector data holdings are perceived to conflict with national interests. This creates potential limitations for smart container adoption by Chinese container owners, particularly where international clients object to their data being accessible or potentially transferred to Chinese authorities. Potential government interventions into the private sector data holdings may also discourage non-Chinese shipping lines from purchasing Chinese IoT equipment if uncertainties around data governance remain unresolved.

China's ambition to strengthen digital and IoT-related governance continues to be constrained by structural fragmentation and coordination deficits that are characteristic of its wider administrative system. Research shows that China's digital governance operates through a multi-layered bureaucratic architecture in which agencies compete for authority, producing overlapping mandates and inconsistent policy execution (Creemers, 2021). Evidence from China's broader cybersecurity governance confirms that implementation is frequently uneven, with regulatory responsibilities distributed across multiple ministries and party bodies whose priorities do not always align (Murniasari, 2024). These tensions are amplified in domains related to cyberspace and data regulation, where even foundational concepts such as "internet sovereignty" are interpreted inconsistently across institutional actors, leading to divergent enforcement practices and policy ambiguity (Huang & Mayer, 2023). Despite these persistent coordination problems, recent reforms signal efforts by the central leadership to consolidate control, streamline governance structures, and impose more uniform standards across the full lifecycle of digital infrastructure and data management. Chinese IoT is also subject to external scrutiny. The Mercator Institute for China Studies (Lee, 2021a) noted that China's growing global IoT footprint exposes Europe and China's trading partners to heightened cyber security concerns due to state involvement in IoT governance. While China's expanding IoT capability stimulates foreign interest in collaboration, ongoing geopolitical tensions with the United States amplify apprehensions surrounding cyber security risks (Lee, 2021a).

Given that smart containers cross multiple jurisdictions and collect data associated with diverse stakeholders, they require harmonised approaches to data governance and cyber security. In this context, standardisation becomes critical. China has established a national committee to focus on container standardisation and participates actively in ISO Technical Committee 104 on freight containers (TC6, 2025). However, it remains unclear whether the Chinese national committee plans to fully report back to ISO TC 104, and whether mutual alignment is systematically achieved. Stronger coordination would benefit both national and international interests, particularly given the cross-border nature of container operations.

Smart container data handling, therefore, highlights a fundamental contrast between contractual, decentralised governance models and state-centric, centralised approaches.

International frameworks tend to rely on private agreements and industry-led standards, whereas China's regulatory system links data governance directly to national strategic interests.

The literature demonstrates, for example Creemers (2021), Murniasari (2024), Huang and Mayer (2023), significant divergence between international contractual models of data governance and China's state centric legal framework, yet it offers little analysis of how these differences influence the adoption and operation of smart container technologies. This gap is especially relevant for understanding China's emerging role as both a provider of IoT hardware and an architect of domestic data regulations that shape cross-border data flows, standardisation potential, and market access. Despite widespread acknowledgement that smart containers generate persistent streams of operational and potentially sensitive data, current research does not examine how China's legal environment constrains, enables, or redirects the governance of such data at the global level. This represents a critical void that this research addresses by analysing how Chinese approaches to data handling, sovereignty, and security influence the technological, organisational, and regulatory diffusion of container digitalisation.

2.4.2 Influence of the Chinese Smart Container Adoption

Having established the global baseline for smart container adoption, this subsection turns to China's state-led logistics strategy to examine how national infrastructure ambitions align with digital supply chain technologies. China's Belt and Road Initiative and, in particular, its Maritime Silk Road component illustrate how physical infrastructure development has become increasingly intertwined with digital strategies. This section explores the geopolitical motivations and digital ambitions underpinning the Maritime Silk Road, with a focus on the role of IoT technologies, connectivity infrastructure, and China's export of smart container capabilities along these routes.

As global trade becomes increasingly digitised, national logistics policies have begun to integrate smart technologies alongside traditional infrastructure. China's Belt and Road Initiative, especially its Maritime Silk Road component, exemplifies this convergence of physical and digital ambitions. The Maritime Silk Road is not merely a trade facilitation project but a state-coordinated strategy that embeds digitalisation within seaborne supply

chains. As Hlongwa (2020) argued, the Maritime Silk Road aims to strengthen China's maritime influence by enabling seamless cargo movement across global trade corridors.

China currently occupies multiple strategic positions within the maritime supply chain. The People's Republic of China (PRC) is one of the world's leading manufacturers of shipping containers, with CIMC reporting record revenues (World Cargo News, 2025). Chinese merged carriers OOCL and COSCO have been recognised as leading operators for containerised United States imports from Asia (Robb, 2025) and are among the five largest container shipping lines globally (Alphaliner, 2025). Given this scale, it is plausible to expect that smart container adoption and broader digital transformation will feature prominently in Chinese maritime logistics, particularly along state-backed strategic corridors.

Various studies have taken differing views on China's motives within the Maritime Silk Road. Thorne and Spevack (2017) and Ameyaw-Brobbey (2018) argued that the Maritime Silk Road forms part of a wider geopolitical project that may leave participating countries heavily indebted to China. In contrast, Brautigam (2009) interpreted China's extensive involvement as a continuation of learning from foreign investment during the 1970s, portraying Chinese engagement as a logical outcome of historical development rather than purely exploitative intent. Chinese efforts along the Maritime Silk Road, whether through the deployment of technology or investments in supporting infrastructure domestically and abroad, exemplify how China seeks to position itself at the centre of the global economy (Hlongwa, 2020). The Maritime Silk Road could, therefore, serve as a vehicle for the international deployment of Chinese smart container technologies, reflecting the strategic intent of the People's Republic of China to position itself as a global provider of logistics technology.

Although maritime power is a relative concept (Till, 2018), developments in the maritime sector illustrate how sea power and technological capability increasingly intersect. By tracing the interaction between national planning, international infrastructure investments, and the deployment of digital tools, this section highlights how the Chinese state frames the role of smart containers within its broader geopolitical and industrial agenda.

In summary, this section has examined smart container adoption through four interconnected dimensions. Firstly, the section has reviewed the conceptual and technological foundations of digitalisation, showing that container digitalisation must be understood within the wider transformation of logistics under Industry 4.0 rather than as an isolated technological development. Secondly, the review has analysed the Internet of Things as the core enabling architecture of smart containers, demonstrating how sensor systems, communication networks and data platforms make real time tracking and condition monitoring technically possible. Thirdly, the section has considered approaches to data handling and the Chinese legal and regulatory context, highlighting that container digitalisation is shaped not only by technical capability but also by competing models of data governance, sovereignty and cross border control. Fourthly, the section has assessed the potential influence of Chinese smart container adoption, indicating that China's industrial scale, digital ambitions and strategic infrastructure position give it the capacity to shape global logistics, while also revealing persistent uncertainty regarding the practical extent, interoperability and international acceptance of Chinese smart container systems. Therefore, it can be surmised from the existing literature that the smart container is not simply a technical device, but a technological, organisational and regulatory phenomenon situated within broader geopolitical and industrial dynamics. At the same time, the review reveals that important questions remain unresolved, particularly concerning the empirical scale of adoption in China, the governance of container generated data and the wider implications of Chinese smart container development for global logistics systems. The following section therefore identifies these unresolved issues as the key research gaps that justify the present study.

2.5 Research Gaps and Research Questions

The review of the existing literature has revealed a series of interconnected gaps in academic knowledge concerning China's smart container adoption, its approach to digital supply chain governance, and the wider implications for the global logistics ecosystem. Although the rapid evolution of track-and-trace technologies and the emergence of IoT enabled, so-called smart containers, have been widely recognised in professional and policy discourse, academic research remains fragmented, conceptually uneven, and empirically limited. The literature is dominated by policy driven narratives, early

conceptual work, and an over reliance on industry announcements rather than independently verified evidence. This Subsection therefore identifies where further academic inquiry is required to support a more robust understanding of China's digital logistics trajectory and its influence on international maritime operations.

Gap One relates to the penetration of smart containers into the Chinese container fleet and their operational influence on the wider supply chain. The current literature acknowledges the historical and contemporary importance of maritime trade routes and the contribution of containerisation to global supply chain efficiency, as demonstrated by authors including Lind et al. (2021), Hansen (2012), Headrick (2016), Levinson (2016), Gereffi and Fernandez-Stark (2016), Yuen et al. (2019), Nie et al. (2019) and the UN ECE CEFACT expert groups. These studies establish a useful foundation for understanding the broader digital transformation of maritime logistics, yet none provide detailed evidence on the extent of smart container deployment within China. Professional sources indicate that Chinese companies such as CIMC and COSCO have introduced IoT enabled initiatives, for example CIMC's AIoT Technology and COSCO's BoxPlus, as identified in Section 1.5. However, the literature does not document the actual scale of adoption, integration into daily operations, or measurable performance outcomes. Independent case studies are absent, including verification of whether state support through tax deductions, strategic funds or innovation incentives, as noted by Yu (2024), Luong, Arnold and Murphy (2021) and Boullenois et al. (2025), contributed to technological uptake. Unlike the detailed professional reporting of fleet wide digitalisation programmes by Hapag Lloyd and ZIM (Section 1.5), where estimated time of arrival accuracy, cargo integrity, security and operational reliability are openly analysed, Chinese deployments remain described primarily in policy aspirational terms COSCO's public claim that one hundred thousand reefer units were digitised is the only quantitative data point, and there is no equivalent information for dry containers, which represent the overwhelming majority of the global fleet. This gap is significant given China's dominant position in global shipping and container manufacturing. Although the general trend of container digitalisation is expected to continue due to global maritime transport carrying approximately eighty percent of world trade volumes (Chen, 2019), the existing literature does not clarify whether China participates in this transition at scale or how smart containers contribute to the operational efficiency of the Chinese supply chain.

Gap Two arises from the incomplete understanding of data governance, cyber security and data sharing rights in relation to smart container operations. The literature identifies core concepts of data sharing and data sovereignty through authors such as Abbas et al. (2024), Scheider et al. (2023), Schweihof et al. (2023), Hellmeier and von Scherenberg (2023) and Opriel et al. (2021). These works describe data sharing as a process in which data providers make information accessible to data consumers in exchange for compensatory benefits, either financial or reciprocal. They also emphasise that baseline rights regarding data control and privacy exist prior to any contractual transaction, and that effective data sovereignty depends on the ability of the data originator to determine conditions for access, use and redistribution. Despite these conceptual contributions, the reviewed literature does not examine how these principles function within logistics specific environments, particularly for IoT enabled smart containers that travel across jurisdictions, interact with multiple transport modes and generate data on a continuous basis.

Although the European Union's Data Governance Act and the General Data Protection Regulation outline detailed frameworks for protecting data subjects and regulating cross-border data access, the operation of Chinese legislation, including the Personal Information Protection Law, the Data Security Law and the Cybersecurity Law, is not analysed in relation to container generated data. Contracts remain a key mechanism for defining rights and obligations in both regions, yet in China the state retains extensive authority to override commercial agreements. Articles 31 and 45 of the Data Security Law restrict cross-border data transfer and grant government agencies broad powers to access stored information on national security grounds. The reviewed literature does not evaluate how these rules are implemented in the context of international logistics, or how they influence the behaviour of companies such as COSCO or CIMC, whose smart container technologies may store or transmit data relevant to cargo operators, agents, shippers, consignees or customs authorities.

Another issue is the absence of empirical studies assessing interoperability between Chinese smart container systems and international digital infrastructures, including port community systems, multimodal tracking platforms or cross-border customs applications. This gap is particularly significant because smart containers are designed to support integrated information flows across supply chain participants, and any disruption to data

exchange would undermine their operational value. The literature acknowledges Western concerns, including those raised by MERICS (Lee, 2021b), regarding the cyber security risks associated with the expansion of Chinese IoT technologies. These concerns stem from the increasing involvement of the Chinese state in regulating data flows, the requirement to localise data storage within the People's Republic of China and the geopolitical tensions between China and the United States. However, the reviewed sources do not provide evidence on whether such concerns affect global adoption, whether they shape procurement preferences among international carriers or ports, or whether they lead to technical isolation of Chinese built systems within segmented logistics corridors.

In summary, despite extensive legal commentary, there is no comprehensive academic analysis of how Chinese data governance principles shape smart container technologies, how contractual autonomy interacts with state authority, or how logistical data is managed across-borders. The absence of operational detail on data handling, cyber security and interoperability therefore constitutes a significant gap in the literature.

Gap Three emerges from the limited examination of the broader implications of Chinese smart container adoption for the international logistics system. Although national strategies such as *Made in China 2025* and the Belt and Road Initiative promote digitalisation, automation and industrial upgrading, the reviewed literature does not analyse whether these agendas have produced measurable outcomes in the smart container sector. China's growing IoT capability is acknowledged, and the introduction of a national standard for refrigerated smart containers, potentially led by COSCO's BoxPlus subsidiary (PRC Communication and Transportation, 2025), indicates a move towards formalising domestic innovation. However, the literature does not assess whether this standard aligns with existing international norms or whether this national reefer smart container standard is compatible with global maritime and intermodal regulations. The international consequences of China's standard setting remain unclear, particularly given the absence of analysis concerning the implications of divergent or parallel standards on interoperability and technology diffusion.

Furthermore, while the literature recognises the growing global footprint of Chinese IoT technology and the associated cyber security concerns raised by MERICS (Lee, 2021b), the reviewed sources do not evaluate whether these concerns affect foreign acceptance of

Chinese smart containers. There is no discussion of how international carriers, port authorities or logistics service providers perceive Chinese built smart container systems, whether issues of vendor dependency or geopolitical tensions influence procurement decisions, or whether these factors slow the global diffusion of Chinese technologies. Even though smart containers are intended to support interoperability across transport modes, there is no analysis of whether Chinese systems integrate effectively with the digital infrastructures of other countries or whether foreign stakeholders view these systems as credible, secure and compatible with their operational needs. The global influence and future trajectory of Chinese smart container technologies therefore remain speculative.

Gap Four follows from the lack of empirical analysis linking China's extensive state support for technological modernisation to the actual development and deployment of smart container systems. Literature identifies substantial tax incentives, research and development deductions and strategic funding mechanisms that support domestic innovation. For example, Yu (2024) reports that approximately 629000 Chinese companies benefited from research and development related tax policies, amounting to trillions of renminbi in deductions. Government Guidance Funds have expanded rapidly, reaching targets of eleven trillion renminbi across more than one thousand seven hundred funds by 2020 (Luong, et al., 2021). Studies by Boullenois et al. (2025) and Wübbeke et al. (2016) further illustrate China's effort to reduce foreign technological dependency and strengthen domestic capabilities. Despite these analyses, there is no academic confirmation that these financial incentives and industrial policies have directly supported the development, commercialisation or deployment of smart container technologies.

Although it is plausible to assume that state backed modernisation, including technological upgrading under *Made in China 2025* and digital logistics strategies under the Belt and Road Initiative, should accelerate adoption of smart containers, the reviewed literature provides no evidence verifying this relationship. There is no documentation of whether Chinese IoT companies involved in container digitalisation received strategic funding, whether market access restrictions for foreign competitors supported domestic players, or whether Chinese built smart containers gained competitive advantage in global markets because of state intervention. The absence of this analysis represents a further

gap in understanding how China's industrial strategy interacts with logistics digitalisation and the smart container industry.

In combination, these four gaps demonstrate that the development, governance and international implications of Chinese smart container technologies have not yet been comprehensively examined. The literature has addressed the historical evolution of maritime logistics and has conceptualised the efficiency potential of smart containers, yet it does not provide empirical depth on China's specific role within this transformation. While professional commentary recognises China's status as a major maritime power, the leading global container manufacturer and a significant investor in digital logistics infrastructure, academic research does not substantiate whether these structural advantages have translated into the widespread adoption or global diffusion of Chinese IoT enabled containers. Likewise, the evidence base remains insufficient to determine whether concerns about cyber security, data localisation or state intervention materially influence international market acceptance of Chinese smart container technologies.

These identified gaps directly inform the research questions of this study. Table 2.1 (Matching Research Objectives with Literature Gaps and Research Questions) provides a structured overview that links the deficits in existing literature to the objectives guiding this project and to the formulation of the research questions. The absence of detailed evidence on the scale and characteristics of Chinese smart container adoption frames the first research question, which investigates China's approach towards using track-and-trace technology for shipping containers. The uncertainty surrounding data governance, the balance between commercial autonomy and state authority and the issue of technical interoperability shapes the second research question, which examines the Chinese perspective on data ownership and data sharing in the digitised supply chain. The incomplete understanding of the potential international influence of Chinese smart container initiatives gives rise to the third research question, which considers how Chinese smart containers may affect global logistics operations and the broader digitalisation trajectory of the maritime sector.

Therefore, the research questions relevant for this study are:

1. What is the Chinese approach towards using track-and-trace technology for shipping containers?

2. What is the Chinese perspective on data ownership and sharing in the digitised supply chain?
3. What is the potential influence of Chinese smart containers on the global logistics system?

In summary, the literature provides useful theoretical insights into digitalisation, data sovereignty and the transformation of global supply chains, but it does not offer sufficient empirical validation, operational transparency or comparative international analysis. The limited evidence on Chinese smart container development, the absence of clarity regarding data governance practices and the lack of assessment concerning global integration collectively justify the need for primary research. Addressing these gaps will require direct engagement with industry stakeholders, examination of the technological and organisational practices underpinning Chinese smart container systems and a systematic analysis of how these practices align with or diverge from international logistics norms. As global maritime logistics evolves towards data centric operational models, understanding China's actual practices rather than its stated ambitions is essential for evaluating how smart container technologies will shape future governance frameworks and for determining their integration within international supply chain networks.

2.6 Summary and Conclusion of the Academic Landscape on Container Digitalisation

This Chapter has reviewed the academic and professional literature relevant to the digitalisation of containerised logistics and China's emerging role within this transformation. Subsection 2.2 outlined the literature search strategy that combined English language databases and Chinese sources to capture both international debates and China specific perspectives. The subsequent sections traced the evolution from containerisation to digital integration. Historical and structural analyses of maritime logistics and global value chains by authors such as Levinson (2016), Gereffi and Fernandez Stark (2016), Lind et al. (2021) and Yuen et al. (2019) established how container shipping became the backbone of international trade and created the conditions for digitalisation to reshape supply chain coordination.

Building on this foundation, Section 2.3 analysed China's international and domestic strategies, reflecting Industry 4.0. by drawing on research on the Belt and Road Initiative, the Maritime Silk Road and *Made in China 2025*. Authors such as Hlongwa (2020), Wei and Ahmed (2018), Yao and Hu (2018), Su (2018) and Neilson (2012) demonstrated how logistics, infrastructure and digitalisation function as instruments of state power and economic influence. Work on *Made in China 2025* and China's industrial policy by Wübbeke et al. (2016), Luong et al. (2021), Boullenois et al. (2025) and the European Union Chamber of Commerce in China (2025) showed that China has invested heavily in domestic innovation, IoT and related technologies, while simultaneously seeking to reduce foreign dependency. Industry and policy sources relating to CIMC, COSCO, BoxPlus and national smart container standards indicated a growing Chinese presence in smart logistics and IoT standards setting.

Section 2.4 examined global smart container adoption and the conceptual and technological bases of logistics digitalisation. Studies by Ivanov (2021), Raza et al. (2023), Becha et al. (2021) and Cortes-Murcia et al. (2022) highlighted both the potential of smart containers and the fragmented, uneven nature of their diffusion. The literature showed that while IoT architectures and real time visibility solutions are technically mature, adoption remains constrained by organisational inertia, cost, lack of standardisation and interoperability problems, as emphasised by Manners- Bell (2023), Pagano et al. (2022) and Tijan et al. (2021). The discussion of the Internet of Things in Section 2.4.1.1 drew on Birkel and Hartmann (2020), Ben Daya et al. (2021) and others to clarify how multi-layer IoT architectures underpin smart container systems, while also revealing that academic work has not kept pace with commercial deployment by carriers such as Hapag Lloyd and ZIM.

Section 2.4.1.2 then turned to data handling and Chinese legal specificities. Conceptual accounts of data sharing, data sovereignty and data governance by Abbas et al. (2024), Scheider et al. (2023), Schweihof et al. (2023), Opriel et al. (2021) and Hellmeier and von Scherenberg (2023) showed how control over data access and reuse has become a central condition for participation in digital ecosystems. At the same time, comparative legal analyses indicated that China's Personal Information Protection Law, Data Security Law and Cybersecurity Law introduce a state centric model of data control that diverges from European and North American contractual approaches (The National People's Congress

of the People's Republic of China, 2021; Cyberspace Administration of China, 2017; Zhang, 2024). Work by Creemers (2021), Murniasari (2024) and Huang and Mayer (2023) further underlined the fragmented and contested character of China's digital governance architecture, while Lee (2021a, 2021b) and other MERICS authors highlighted external concerns about cyber security and dependency on Chinese IoT infrastructure. However, as Section 2.4.1.2 showed, these debates have not yet been connected systematically to container specific IoT deployments. Therefore, the potential influence of the Chinese smart container adoption is expected to be significant but yet is hard to be systemically measured.

Yet, the sections 2.3 till 2.4 concluded, academic work has not established whether these strategies have translated into large scale, empirically verifiable smart container adoption or into globally interoperable systems. The synthesis in Section 2.5 distilled these observations into four explicit research gaps. *Gap One* concerned the lack of independent empirical evidence on the scale, characteristics and operational consequences of Chinese smart container deployment, despite China's structural importance in shipping and container manufacturing. *Gap Two* addressed the incomplete understanding of how Chinese data governance laws and sovereignty claims operate in practice for container generated data, and how these interact with international contractual models and interoperability requirements. *Gap Three* highlighted the limited analysis of how Chinese smart container initiatives may influence global logistics operations, standardisation processes and technology diffusion in an environment of strategic rivalry and cyber security concern. *Gap Four* identified the absence of detailed examination of the relationship between China's extensive state support for digitalisation and the specific development and deployment of smart container systems.

Table 2.1 "Matching Research Objectives with Literature Gaps and Research Questions" formalises the relationship between these gaps, the objectives of the study and the formulation of the research questions. The absence of verified knowledge on Chinese adoption patterns underpins *Research Question One*, which investigates China's approach towards using track-and-trace technology for shipping containers. The unresolved issues surrounding data governance, sovereignty, commercial autonomy and technical interoperability shape *Research Question Two*, which examines the Chinese perspective on data ownership and data sharing in the digitised supply chain. The limited

understanding of the international implications of Chinese smart container initiatives leads to *Research Question Three*, which considers the potential influence of Chinese smart containers on the global logistics system and on the wider trajectory of maritime digitalisation.

Together, the literature reviewed in Sections 2.3 to 2.6 demonstrates that while there is a substantial conceptual and policy-oriented discussion of digitalisation, IoT and Chinese industrial strategy, there is a marked lack of empirically grounded analysis at the level of container technologies and their governance. The Chapter has shown that existing research does not adequately explain how Chinese actors adopt and interpret smart containers, how container data are governed within China's legal and institutional framework or how these developments may affect global logistics interoperability. These deficits justify the need for primary qualitative research with Chinese industry and policy actors.

Chapter Three therefore introduces the theoretical framework that will be used to interpret the empirical findings. The Chapter brings together developmental state theory, the technology-organisation-environment framework, data governance debates and institutional theory to provide the structured analytical lens required to address the research questions derived from the gaps identified in this Literature Review. Chapter Three develops the theoretical framework required to analyse these issues, providing the conceptual structure through which the findings of this study will be interpreted.

Table 2.1 Matching Research Objectives with Literature Gaps and Research Questions

Research objectives	**RQ1: Chinese approach to track-and-trace**	**RQ2: Chinese perspective on data ownership and sharing**	**RQ3: Potential global implications of Chinese smart container technologies**
Objective 1. Identify, through a critical review of the literature, how track-and-trace technology has been conceptualised and adopted within Chinese container maritime transport.	**Gap 1.** Foundational studies on containerisation and maritime digitalisation (Levinson, 2016; Lind et al., 2021 Becha et al., 2021) do not examine the extent of smart container deployment in China. **Gap 4.** Industrial policy analyses (Wübbeke et al., 2016) do not assess whether tax incentives or strategic funding influence China's adoption of smart containers.	**Gap 3.** Chinese data governance (Zhang, 2024, Huang, 2024, Lee 2021b) does not address data ownership or data - sharing practices within the digitised supply chain or at the level of container operations.	-
Objective 2. Analyse empirically the Chinese approach to using track-and-trace technology on Chinese-owned containers operating in global logistics.	**Gap 1.** Lack of empirical evidence on deployment levels within China, which Objective 2 addresses. **Gap 4.** No evidence linking industrial policy tools to adoption (Wübbeke et al., 2016).	-	**Gap 2.** General IoT and maritime cybersecurity studies (Lee, 2021b; Lee 2021a; Murniasari, 2024; Creemers, 2021; Huang & Mayer, 2023) do not analyse cybersecurity concerns specific to Chinese smart container devices or telematics systems.
Objective 3. Evaluate the Chinese perspective on data ownership and	-	**Gap 3.** As above, Chinese data governance (Zhang, 2024, Huang, 2024, Lee	-

Research objectives	**RQ1: Chinese approach to track-and-trace**	**RQ2: Chinese perspective on data ownership and sharing**	**RQ3: Potential global implications of Chinese smart container technologies**
data sharing within the digitised supply chain.		2021b; Huang & Mayer, 2023) does not address data ownership or sharing in containerised logistics. **Gap 3 (extended).** Global data-sharing frameworks (UN CEFACT, 2019 Chen, 2019) do not examine how Chinese actors reconcile national sovereignty requirements with global interoperability.	
Objective 4. Interpret the empirical findings in relation to China's industrial policy goals to clarify how Made in China strategies shape container-level digitalisation.	**Gap 4.** Industrial policy frameworks (Wübbeke et al., 2016) do not link Made in China strategies to container-level digitalisation.	**Gap 3.** No literature connects China's national data governance approach with the practical requirements of international supply-chain interoperability (UN CEFACT, 2019; Chen, 2019).	**Gap 4.** BRI financing literature (Su 2018; Yao & Hu, 2018) does not assess whether industrial incentives extend to smart container technology internationalisation.

3 Theoretical Framework

3.1 Positioning the Theoretical Framework within the Study

To structure the analytical foundations of this study, a theoretical framework is required to connect the identified research gaps with a coherent explanatory model. Following Yin's analytic logic for case study research, this study adopts an input, process and output structure to organise the theoretical constructs shaping the research (Yin, 2018). This structure provides a systematic means of linking contextual determinants, observed activities and the resulting empirical or conceptual outcomes, while also offering a clear pathway through which the empirical questions of the study can be explored. The model is particularly suitable for complex, multi layered cases in which technological, institutional and geopolitical factors interact, as is the case with China's digitalisation of its container fleet.

In the context of this study, the input dimension reflects the core conditions and structural factors that shape China's approach to container digitalisation. These include China's position as the dominant global container manufacturer, the strategic influence of state led industrial policies such as *Made in China 2025*, the logistical ambitions embedded in the Belt and Road Initiative and the interplay between national data governance laws and international technological expectations. These elements constitute the foundational drivers of China's container digitalisation trajectory and define the environment in which smart container technologies are produced, deployed and evaluated. They also include broader institutional and geopolitical determinants, such as Chinese state support for strategic industries, the global expansion of Chinese IoT ecosystems and the concerns expressed by international actors regarding cyber security and data localisation. Taken together, these factors form the starting conditions of the study and align directly with the first research gap concerning the uncertain scale and nature of Chinese smart container adoption.

The process dimension concerns the activities and mechanisms through which digitalisation unfolds within the Chinese container ecosystem. This includes the technological integration of IoT enabled hardware such as sensors, communication modules and telematics devices into container fleets, and the associated data processing, storage and sharing practices. This dimension also encompasses the institutional processes that shape data governance and security, including the operation of China's Personal Information Protection Law, the Data Security Law and the Cybersecurity Law. These processes influence how logistical data is collected, who is authorised to access or share data and how contractual autonomy interacts with overarching state authority. Furthermore, this dimension includes the organisational and market responses to Chinese smart container technologies, both domestically and internationally. Activities such as standard setting, technological testing, integration with digital port systems and stakeholder acceptance form part of this process. This dimension directly aligns with the second research gap concerning the unresolved issues of data ownership, interoperability and cyber security.

The output dimension reflects the observed or expected consequences derived from the interaction between the input conditions and the digitalisation processes. These outputs include the potential influence of Chinese smart container technologies on global logistics operations, the implications for international data governance norms and any emerging effects on interoperability, visibility, cargo security or supply chain coordination. The output stage also encompasses wider geopolitical and economic consequences, such as the possibility that Chinese technologies could establish parallel technical ecosystems, shape international standards or affect global trust in digital maritime infrastructure. This dimension aligns with the third research gap concerning the international implications and market acceptance of Chinese smart container systems.

The adoption of Yin's (2018) input, process and output model provides a structured analytical mechanism for examining China's digitalisation trajectory. The construct enables a clear distinction between contextual conditions, operational activities and observable consequences. The approach also provides a coherent framework through which the three research questions can be addressed. The *first research question* relates to the input dimension, as it focuses on the contextual and institutional drivers of China's approach to track-and-trace technologies. The *second research question* connects to the

process dimension, as to examining the practices, mechanisms and constraints surrounding data ownership and data sharing within the Chinese regulatory landscape. The *third research question* aligns with the output dimension, as the focus is on investigating the potential influence of Chinese smart containers on global logistics systems and digital supply chain governance.

This theoretical framework therefore serves as the analytical foundation for the subsequent empirical examination. The strategy provides a structured means of linking the literature to the research design and supports a systematic evaluation of how China's container digitalisation unfolds across institutional, technological and geopolitical levels.

The subject of this research, the digitalisation of Chinese container fleets and the implications for global logistics, operates simultaneously at technological, organisational, regulatory and geopolitical levels. One theoretical tradition could not sufficiently capture these interacting dimensions; therefore, a multi-layered explanatory architecture is required. Reflecting this, it is necessary to present the fundamental theories commencing with the developmental state theory. Developmental state theory justifies the strategic intent and institutional capacity underpinning China's industrial upgrading. However, the strategy does not explain how companies operationalise innovation or how technology adoption unfolds at organisational level. The next concept is the technology-organisation-environment framework which could provide an insight into company-level adoption dynamics but treats state intervention as part of the external environment rather than as an architect of structural conditions and may lack a macro-political dimension. In contrast, data governance and sovereignty theory could clarify the regulatory logic shaping ownership, access and cross-border control of digital logistics data. However, the concept does not explain why specific governance models emerge in the first place or how they are embedded in broader industrial strategy. The next concept is the institutional theory, which explains legitimacy, diffusion and normative alignment across jurisdictions. However, the theory does not provide a detailed account of technological architecture or state-led industrial coordination.

Based on above, the integration of these four perspectives therefore allows the study to move from strategic intent to organisational implementation, to regulatory configuration, and finally to international diffusion. This layered structure enables the comprehensive

theoretical framework, which ensures that each research objective is addressed through a theoretically appropriate analytical lens.

The next section builds on this framework by introducing the first of the theoretical perspectives that shape the analysis, namely the developmental state tradition and its associated industrial policy logic, before progressing to the technology-organisation-environment framework, data governance and sovereignty theory and institutional explanations of geopolitical digitalisation.

3.2 Developmental State Theory and Strategic Industrial Policy

A core concern of developmental state theory is the state's active role in shaping industrial development, including its influence over the geographic distribution, technological upgrading and strategic positioning of key industries (Johnson, 1999; Amsden, 2001). Johnson (1999), Amsden (2001) have demonstrated that developmental states deliberately select strategic sectors, steer technological upgrading and determine the spatial allocation of industries to advance long term national development objectives rather than short term market forces (Johnson, 1999; Amsden, 2001; Evans, 1995; Wade, 2018). In this sense, developmental state theory provides a means of analysing not only how states intervene in markets, but also why they do so and with what consequences for industrial transformation. Chang (1999) and Wade (2018) further emphasise that state intervention serves the structural transformation of the economy, enabling governments to guide industrial composition, accelerate technological upgrading and restructure institutional frameworks in pursuit of national strategic ambition.

China's state led industrial strategy exhibits the defining characteristics identified in developmental state literature. Loriaux (1999) and Evans (1995) argue that developmental states combine autonomy from societal interests with embeddedness in selected networks, which allows them to pursue coherent development agendas while mobilising institutional capacity to implement them. For this study, these principles are directly relevant to *Research Question One*, which examines the Chinese approach to integrating track-and-trace technology into shipping container logistics. Developmental state theory, therefore, provides a conceptual explanation for how national policy, state

financing and institutional coordination influence China's choices regarding smart container adoption.

These attributes are visible in China's centralised strategic initiatives, including *Made in China 2025* and the Belt and Road Initiative. Wei and Liefner (2012) argue that China's industrial location patterns, particularly in logistics and manufacturing, are shaped by state intervention rather than market allocation alone. This observation suggests that classical location theory, be adjusted to account for strong state involvement in countries such as China. In this context, industrial placement, logistics infrastructure and technological development are politically guided instruments that serve broader national objectives.

China's state driven policies illustrate this strategic function. *Made in China 2025* and the Belt and Road Initiative operate as core drivers of logistics digitalisation and industrial upgrading. These policies embody the principles of the developmental state by directing innovation, incentivising domestic technological production and reducing dependence on imported technologies (Wübbeke et al., 2016; Boullenois et al., 2025). Government Guidance Funds represent a significant mechanism through which the state mobilises strategic investment, with more than eleven trillion renminbi allocated across more than one thousand seven hundred investment vehicles targeting sectors including semiconductors and industrial IoT (Luong et al., 2021). Further support through tax incentives and extensive research and development deductions strengthens domestic technological capability and competitiveness (Boullenois et al., 2025; Yu, 2024).

These interventions coincide with the emergence of proprietary smart container technologies developed by Chinese companies, including CIMC AIoT and COSCO's BoxPlus. The introduction of a national standard for smart refrigerated containers in 2025 reflects an intention to consolidate domestic technological capability and advance Chinese specifications internationally (PRC Communication and Transportation, 2025). Such standardisation efforts demonstrate a strategic ambition not only to modernise domestic logistics infrastructure but also to influence the global normative framework for supply chain technologies. This aligns with Loriaux's and Evans's observations that developmental states seek not only domestic economic transformation but also normative influence over international industrial systems.

Several authors, including Hlongwa (2020), Thorne and Spevack (2017), Conte (2023) and Chen (2019), argue that the digitalisation of Chinese container fleets should be interpreted within a wider strategy aimed at strengthening Chinese economic and technological influence. Their analysis connects state driven initiatives such as the Belt and Road Initiative and *Made in China 2025* with the deployment of smart containers as instruments of economic projection and technological leverage. These interpretations reinforce the claim that industrial geographies in developmental state contexts cannot be understood without recognising state influence over sectoral clustering, technological diffusion and infrastructure expansion.

Although some authors, for example Evans (1995) and Johnson (1999) argue that classical developmental states have weakened under globalisation, others maintain that the model has evolved rather than declined. Chang (1999) and Wade (2018) suggest that strategic state guidance continues through new instruments, including regulatory coordination, targeted investment and refined industrial policy tools. Loriaux (1999) notes that the moral and strategic ambition of the developmental state persists, even as its methods adapt to contemporary international conditions. These observations are of relevance to this study, as they demonstrate that China's current industrial strategies represent a contemporary extension of developmental state principles, rather than a departure from them.

In conclusion, the Chinese case illustrates a modern adaptation of developmental state theory in which the state retains a central and strategic role in shaping industrial development, technological innovation and spatial planning. Through policy frameworks, funding mechanisms and standardisation initiatives, China strengthens domestic capabilities while extending its influence across global supply chains. This sustained and evolving state involvement provides a strong theoretical foundation for analysing China's logistics digitalisation and supports an informed examination of its approach to smart container technologies. Developmental state theory therefore offers critical conceptual grounding for addressing *Research Question One* and understanding China's strategic and institutional capacities within an increasingly globalised yet politically fragmented maritime logistics environment. Developmental state concept clarifies why China prioritises container digitalisation within a broader strategy of technological self-reliance

and industrial upgrading. The theory also supports *Objective Four* by linking empirical findings to *Made in China 2025* and Belt and Road ambitions.

However, this theory does not explain how individual companies evaluate, adopt or resist specific digitalisation technologies. Furthermore, the concept does not specify how data governance mechanisms operate in practice. Instead, the theory can provide an explanatory strength, which lies in strategic orientation rather than in operational dynamics. This limitation necessitates integration with company-level and governance-focused frameworks.

3.3 Technology-Organisation-Environment (TOE) Framework

A further theoretical contribution to understanding the Chinese approach to integrating track-and-trace technologies into its container fleet is provided by the technology-organisation-environment framework. Originally developed by Tornatzky and Fleischer (1990), the TOE framework explains how companies evaluate, adopt and implement innovations by examining three interconnected dimensions. These dimensions include the technological context, the organisational characteristics of the adopting entity and the external environment in which the adoption process unfolds, as defined in the foundational model (Tornatzky & Fleischer, 1990; Baker, 2012). Unlike macro level theoretical approaches, the TOE model is a company level analytical framework that clarifies why organisations with similar access to technology may nevertheless differ in their adoption decisions (Oliveira & Martins, 2011).

The technological dimension concerns the availability, maturity and perceived usefulness of relevant innovations. In the context of smart containers, this includes the reliability of IoT sensors, the stability of communication networks, energy efficiency, the durability of telematics devices and the capacity for integration with existing logistics platforms. Although IoT technology has progressed significantly in recent years, its adoption across container fleets remains uneven. COSCO has publicly reported the deployment of one hundred thousand smart refrigerated containers, yet there is little verified information on dry container digitalisation. By contrast, shipping lines such as Hapag-Lloyd and ZIM have achieved full fleet digitalisation for dry containers using non-Chinese technology

providers, including Nexxiot, Hoopo and ORBCOMM, as shown in Section 1.5. This contrast highlights that technological readiness alone does not guarantee adoption.

The organisational dimension refers to the internal structures, resources and strategic orientations of companies. This aspect encompasses leadership commitment, financial capacity, strategic priorities, internal competencies and the ability to coordinate technological change. Within China, the organisational characteristics of major companies such as COSCO and CIMC play a significant role in shaping the adoption trajectory of smart containers. Zhang et al. (2025) identified persistent operational challenges in assets digitalisation, suggesting that organisational structures may not yet be fully aligned with large scale deployment. These internal constraints help to explain why China's adoption pattern differs from that of Western carriers despite the availability of similar technological solutions.

The environmental dimension addresses the external pressures and enabling conditions that influence adoption. These include sectoral competition, regulatory frameworks, infrastructural compatibility, industry expectations and the presence of technology providers within the market. The organisational discourse surrounding digitalisation, as discussed by Herold et al. (2021), suggests that adoption is shaped not only by cost benefit considerations but also by institutional narratives that influence perceived legitimacy, necessity and timing. The absence of harmonised standards, uncertainty regarding data governance and the fragmented regulatory environment identified earlier in the Chapter contribute to an uneven adoption landscape. These environmental constraints are particularly relevant in China, where national regulatory frameworks, market incentives and geopolitical sensitivities intersect with the operational needs of global logistics.

Together, the three dimensions of the TOE framework provide an analytical structure for interpreting the drivers and barriers that shape China's smart container adoption. The model explains why progress remains inconsistent despite strong state support and significant advances in IoT technology. The strategy also clarifies the interaction between internal organisational dynamics, external regulatory conditions and technological capabilities, which is central to understanding China's approach to container digitalisation.

The TOE framework is directly relevant to this study because it aligns with Yin's process dimension (Yin, 2014) by illuminating the mechanisms through which digitalisation unfolds within organisations. The framework also contributes to addressing *Research Question One* by showing how Chinese companies evaluate and respond to technological innovation within the constraints of their institutional and competitive environment. TOE therefore complements the developmental state perspective by focusing on the company level dynamics that mediate the implementation of national strategies. This provides a conceptual bridge to the next subsection, which examines data governance and sovereignty as critical environmental conditions influencing the operational processes of digitalisation.

Therefore, the TOE framework can contribute directly to *Objectives One* and *Two* by explaining the organisational and technological determinants of adoption. The framework can enable a systematic analysis of why Chinese companies may differ in digitalisation speed despite similar state incentives.

However, TOE conceptualises the external environment as a contextual factor rather than as a politically constructed system. It should be noted that the concept does not theorise geopolitical strategy or national industrial ambition. Furthermore, the construct does not address cross-border data sovereignty or legitimacy challenges. Therefore, TOE requires integration with developmental state and data governance theory to capture the full scope of China's digitalisation trajectory.

3.4 Data Governance and Sovereignty Framework

The data governance and sovereignty component of this study's theoretical framework is essential for addressing *Research Question Two*, which examines the Chinese perspective on data ownership and data sharing in the digitised supply chain. China's regulatory approach, articulated through the Data Security Law, the Personal Information Protection Law and the Cybersecurity Law, reflects a statist model in which data is conceived as a sovereign asset rather than a commodity governed primarily by contractual relationships (Zhang, 2024). Article 35 of the Data Security Law, which prohibits the unapproved transfer of data to foreign authorities, illustrates a state centred vision of data governance that prioritises national security and political control. This model diverges sharply from

Western regulatory traditions, which rely on private law principles, individual rights, and transnational data flow grounded in contractual autonomy or rights-based frameworks (Offor, 2020; Creemers, 2021).

China's framework treats data, including non-personal, industrial and logistical data, as a strategic national resource. This aligns with what Aaronson (2021) describes as authoritarian digital mercantilism, a form of digital governance in which states deploy data regulations to enhance national competitiveness, assert territorial control in cyberspace, and restrict foreign access to strategically valuable information. These developments reflect broader theoretical debates on the elasticity of sovereignty, where states extend territorial jurisdiction into digital environments to maintain authority over transboundary data flows (Couture & Toupin, 2019). This sovereign elasticity is particularly pronounced in the governance of Internet of Things data in logistics systems, such as that generated by smart containers. Although much of the data captured by such devices does not qualify as personal data, its commercial relevance, operational utility and potential strategic value justify state intervention and classification under national security considerations (Hummel et al., 2021).

The LOGINK platform illustrates how China operationalises its data governance framework within logistics digitalisation (USCC, 2022). Developed by the Ministry of Transport and later integrated into the Belt and Road Initiative, LOGINK functions as a centralised logistics data infrastructure with ambitions of international uptake. Its expansion to more than twenty-four international ports and its interoperability agreements with state owned enterprises, including COSCO, create significant potential for Chinese authorities to access granular data on global freight flows (Aaronson, 2021). Such visibility raises questions about the extraterritorial application of Chinese data governance norms and the scope of state access to commercial logistics data collected beyond China's territorial borders.

LOGINK implements China's regulatory approach by embedding national standards within the platform's architecture and by promoting participation as an efficiency enhancing public good (USCC, 2022). While this model facilitates data integration, its centralised structure enables pervasive state oversight, even as logistics operations cross international jurisdictions. This challenges conventional assumptions about neutral data

exchange in global supply chains and complicates the prospects for global interoperability. The platform's technical design supports the state's ability to monitor, aggregate or redirect data through Chinese infrastructure, thereby positioning data governance as a strategic lever of international influence (Couture & Toupin, 2019; Hummel et al., 2021).

This regulatory configuration contributes to what Hummel et al. (2021) describe as a structural tension between data access and control, where sovereign imperatives override collaborative transparency. The implications extend into multilateral regulatory ecosystems, including initiatives led by ISO and UN CEFACT, which rely on consensual and interoperable data frameworks. LOGINK therefore illustrates how digital infrastructure embeds political rationalities within global value chains and reflects a distinctive Chinese approach to governing data in cross-border logistics (Aaronson, 2021). This approach raises a wider dilemma for global supply chain digitalisation, since real time data from smart containers is crucial for safety, efficiency and cargo integrity, but the governance structures that manage such data may privilege national interests over shared standards. This may impair trust, inhibit data portability and weaken compliance across jurisdictions (Aaronson, 2021).

Viewed through the theoretical lens of data sovereignty and platform governance, the case of Chinese smart containers demonstrates that digital infrastructures are not neutral. Rather, as argued by Zuboff (2019) and Hummel et al. (2021), infrastructures are sites where legal, political and economic orders are inscribed and contested. China's data governance architecture might influence not only which actors can access smart container data, but also how this data can be shared, stored or leveraged within global supply chains. In logistics systems reliant on interoperability, the interaction between national regulatory authority and international data flows becomes a critical point of analysis.

In summary, this subsection establishes the theoretical foundations for understanding data governance and data sovereignty in relation to Chinese smart container adoption. Drawing on regulatory theory, digital sovereignty research and infrastructural governance studies, data is conceptualised not merely as a technical artefact but as a politicised object subject to national strategic interests. This perspective clarifies how the tension between operational efficiency and regulatory control shapes the movement, accessibility and

reliability of smart container data across-borders. The framework therefore directly supports the analytical aims of this study by providing conceptual tools for evaluating China's approach to digital logistics infrastructure and the implications for global supply chain interoperability. Data governance and sovereignty theory is central to *Research Question Two* and *Objective Three*. The theory provides the conceptual tools to analyse ownership rights, cross-border transfer constraints and regulatory asymmetries in digital supply chains.

However, this perspective focuses primarily on regulatory control. The data governance and sovereignty framework does not explain the organisational decision-making processes behind adoption, nor the strategic industrial logic motivating state regulatory design. Without integration with developmental state theory, the governance framework risks appearing reactive rather than strategic. Without TOE, the outcme lacks micro-level implementation analysis.

This analysis also prepares the ground for the next subsection, which applies institutional theory to examine how geopolitical tensions and normative contestation influence the international acceptance of Chinese smart container technologies.

3.5 Institutional Theory and Geopolitical Digitalisation

Institutional theory complements the developmental and data governance perspectives by explaining how regulatory environments, standard setting processes and shared social norms shape organisational behaviour. This perspective is directly relevant to *Research Question Three*, which examines the potential global influence of Chinese smart container technologies. Institutions, understood through Scott's (2014) regulative, normative and cultural cognitive pillars, provide the wider context in which organisations evaluate the legitimacy, desirability and feasibility of technological innovations. In the case of smart containers, institutional pressures could take the form of government incentives, formal regulations, emerging data governance norms and evolving expectations regarding interoperability and security. These forces collectively might influence the capacity of Chinese technologies to diffuse beyond domestic markets.

As Scott (2014) emphasised, the regulative pillar holds particular significance in domains where states impose rules and compliance requirements to shape organisational behaviour. China's introduction of a national standard for smart refrigerated containers, potentially led by COSCO and formalised through the Standardisation Administration of China, exemplifies the role of regulatory instruments in operationalising national technological preferences (PRC Communication and Transportation, 2025). Such standardisation efforts illustrate how national institutions structure the design, functionality and data characteristics of smart container systems. The level of alignment between Chinese national standards and international norms therefore becomes a critical determinant of whether Chinese solutions can integrate within global logistics networks.

The geopolitical dimensions of China's logistics digitalisation further reinforce the relevance of institutional theory. Researchers including Thorne and Spevack (2017), Ameyaw-Brobbey (2018) and Chen (2019) interpret China's investment in digital infrastructure as a strategic tool for expanding international influence. Their analyses suggest that technologies, standards and platforms introduced under initiatives such as the Belt and Road Initiative form part of a broader strategy to shape supply chain governance and embed Chinese institutional preferences within global value chains. Wang et al. (2025) similarly argue that automation and planning systems are used not only to enhance operational efficiency but also to structure the normative environment of global logistics. When combined with data governance mechanisms, container digitalisation could become an instrument of state power that might project regulatory authority and influence patterns of global data flow.

Institutional theory also informs the design of this study's empirical components. Interview questions such as "Which standardisation bodies do you and your company participate in, and why?" or "To what extent is digitalisation subsidised by your government?" are grounded in Scott's (2014) conceptualisation of institutional logics and agency. These questions help reveal how organisations navigate competing institutional pressures, including national regulations, international standards, commercial incentives and geopolitical expectations. These activities and requirements are particularly important in a globalised logistics sector, where Chinese companies operate within transnational networks that may embody conflicting institutional logics, for example liberal approaches to data openness versus state centred models of digital sovereignty.

The geographic breadth of maritime and intermodal container transport also underscores the institutional challenges associated with Chinese smart container technologies. As containers traverse jurisdictions governed by diverse regulatory regimes, the extent to which Chinese systems align with or diverge from international institutional expectations becomes central to their acceptance. The diffusion of Chinese smart container technologies is therefore shaped not only by technical compatibility or commercial incentives but also by institutional legitimacy, regulatory equivalence and perceptions of geopolitical risk.

Institutional theory adds an essential normative and symbolic dimension to the wider theoretical framework developed in this Chapter. The theory clarifies how the legitimacy of Chinese smart container technologies is shaped by formal rule systems, international standardisation processes and the geopolitical framing of digital infrastructures. When combined with developmental state theory, TOE and data governance perspectives, institutional theory helps explain why seemingly efficient technologies may face resistance or differential uptake across global markets. The institutional theory also illuminates the mechanisms through which China may seek to shape international supply chain norms and the circumstances under which such efforts might be contested.

Institutional considerations are also central to the formulation of the three potential international influence scenarios. A domestic only scenario would reflect the dominance of national institutional logics within China, with minimal external validation or alignment. A regional diffusion scenario, focused on Belt and Road partners, would reflect institutional proximity and political affinity. A global integration scenario would depend on institutional convergence, including the harmonisation of standards, enhanced transparency in data governance and mechanisms to ensure trust in cross-border data exchanges.

Therefore, institutional theory highlights the importance of legitimacy, acceptance and regulatory alignment as preconditions for the broader diffusion of Chinese smart container technologies. The theory also underscores that data generated by these systems occupies a contested space shaped by conflicting institutional logics between national security preferences and global operational requirements. These tensions directly

influence the perceived trustworthiness and scalability of Chinese technologies in international logistics.

In conclusion, institutional theory strengthens the analytical structure of this study by providing insight into the normative, regulatory and symbolic dimensions of Chinese container digitalisation. This theory connects the technical and organisational processes of adoption with broader geopolitical and regulatory contexts. Institutional theory addresses *Research Question Three* by explaining how legitimacy, standardisation alignment and geopolitical framing influence international diffusion. The theory clarifies why technological capability alone does not guarantee global acceptance.

However, institutional theory does not explain how technologies are engineered, financed or governed domestically. The concept also does not account for strategic industrial intent. Instead, the institutional theory complements but does not replace developmental, organisational and governance perspectives.

By integrating institutional theory with developmental, organisational and data governance perspectives, the research is positioned to investigate not only how China develops and deploys smart container technologies but also how these technologies may reshape, or be constrained by, the institutional architecture of global supply chains.

3.6 Summary and Conclusion of the Theoretical Framework

The integrated theoretical framework developed in this Chapter operates across four analytical layers. Developmental state theory conceptualises the strategic and political drivers of digitalisation. The technology-organisation-environment framework illustrates how organisational implementation dynamics exists. Data governance and sovereignty theory explains regulatory control and cross-border constraints. Institutional theory explains legitimacy, diffusion and normative contestation at international level.

Each theory addresses a distinct dimension of the research objectives. *Objective One* is informed by developmental state theory and TOE, linking strategic ambition to company-level adoption. *Objective Two* is illuminated by TOE and data governance theory, contextualising the operational digitalisation mechanisms. *Objective Three* relies primarily on data governance and sovereignty perspectives. *Objective Four* integrates all four theories to interpret global influence and geopolitical implications.

Research Question One is addressed through the interaction between developmental state theory and TOE. *Research Question Two* is addressed through data governance theory, contextualised within state strategy. *Research Question Three* is addressed through institutional theory, supported by insights from industrial policy and governance structures.

Upon closer examination, developmental state theory enables a nuanced understanding of China's industrial strategy and its strategic deployment of digital technologies. The role of the state in directing economic development, exemplified through initiatives such as *Made in China 2025* and the Belt and Road Initiative, reveals an enduring capacity to steer technological innovation and infrastructure modernisation. This theoretical lens allows the research to examine how state led strategies shape the scope, direction and limitations of smart container deployment within both national and international contexts.

The technology-organisation-environment framework enriches this analysis by providing a detailed view at the organisational level. TOE clarifies how technological readiness, internal organisational alignment and external environmental pressures influence the

adoption of smart container technologies. The differing adoption patterns between Chinese and non-Chinese companies underscore the importance of internal capacity, regulatory maturity and the surrounding competitive ecosystem. TOE therefore supports the identification of structural and organisational factors that enable or constrain innovation diffusion.

The data governance and sovereignty perspective introduces a vital regulatory dimension. China's treatment of data as a strategic national resource, reinforced through instruments such as the Data Security Law and operationalised through platforms like LOGINK, has significant implications for cross-border data flows and international collaboration. This approach contrasts strongly with models that conceptualise data as a transactable commodity. Understanding this divergence is essential for evaluating how Chinese smart container technologies align with or challenge global expectations regarding transparency, interoperability and regulatory reciprocity.

Institutional theory adds a further layer of analytical depth by explaining how norms, standards and regulatory pressures shape organisational behaviour and technology diffusion. The regulative, normative and cultural cognitive dimensions of institutions influence the legitimacy and acceptance of smart container technologies across jurisdictions. The alignment of Chinese national standards with international norms therefore becomes a central question in determining whether these technologies can diffuse beyond domestic markets and Belt and Road partner regions.

Combined these four theoretical perspectives converge to form a coherent analytical architecture for the study. These concepts illuminate both the structural conditions and the agency driven processes shaping smart container adoption, and how theories situate the developments within a broader geopolitical and regulatory landscape. This integrated framework guides the formulation of the research design and supports the development of feasible and analytically grounded objectives.

The four research objectives, centred on domestic adoption, data governance practices and global interoperability, are each directly supported by the theoretical constructs outlined in this Chapter. The alignment between theory and empirical focus ensures conceptual coherence and methodological rigour. The Chapter also identifies several critical gaps in the existing academic and empirical literature. The first major gap is

concerned as to the limited evidence on smart dry container adoption within Chinese fleets. While companies such as COSCO have publicised the deployment of smart reefer units, there is little transparency regarding the scale and functionality of dry container digitalisation. This stands in contrast to the fully digitalised fleets of Hapag Lloyd and ZIM, which have openly documented their adoption. This gap indicates the need for empirical investigation into the technological, organisational and political conditions shaping adoption within China.

A second gap is focused on the limited application of the technology, organisation and environment framework to state driven logistics sectors. The interaction between state mandated innovation, organisational readiness and external market dynamics remains underexplored in the literature. This gap suggests that the TOE framework requires contextual adaptation to accurately capture innovation processes within China's political economy.

A further gap lies in the insufficient examination of data governance and sovereignty within the logistics sector. Although China's digital governance model has been widely analysed, its specific application to container technologies and cross-border data flows remains understudied. In particular, the implications of exporting Chinese data norms through platforms and standards have not been systematically addressed.

The literature also reveals a gap in the application of developmental state theory to contemporary digital logistics infrastructure. Existing analysis tends to focus on traditional manufacturing or advanced technologies such as semiconductors, often overlooking the logistical infrastructures that underpin global trade. Smart container technologies, which combine manufacturing, telecommunications, data infrastructure and transport services, represent a critical site for examining the contemporary manifestation of the developmental state.

Finally, the domain of global interoperability and standardisation has received limited attention in relation to Chinese smart containers. Although Chinese actors increasingly participate in international standardisation bodies, the implications for mutual recognition, trust and regulatory convergence remain unclear. This research aims to contribute to this underdeveloped area by examining how Chinese technological standards are positioned and contested within global governance forums.

By identifying and addressing these gaps, the research establishes its relevance and contributes to academic and policy debates on digitalisation and supply chain governance. The theoretical framework developed in this Chapter functions as an analytical guide for the empirical investigation that follows. The defined framework provides a structured basis for examining the political, organisational and regulatory forces shaping the development and diffusion of smart container technologies within a globally integrated yet politically fragmented maritime logistics environment.

Table 3.1 Theoretical Framework Matrix

Yin's structure	Theoretical lens	Key authors	Core analytical themes	Connection to research questions and objectives
Input	Developmental state theory	Evans (1995), Loriaux (1999), Wade (2018), Wei and Liefner (2012)	State led industrial strategy, Made in China 2025, Belt and Road Initiative, Government guidance funds, strategic localisation; state involvement in logistics digitalisation.	**RQ1: Objective One and Two**. Explains structural drivers of China's approach to track-and-trace technologies.
Process	Technology Organisation Environment (TOE)	Tornatzky and Fleischer (1990), Baker (2012), Herold et al. (2021)	Technological readiness, organisational capacity, external environment, IoT capability, market pressures, internal alignment within companies.	**RQ1: Objective One**. Identifies company level determinants of adoption decisions. Objective Two: empirical analysis of adoption mechanisms.
Process	Data governance and sovereignty	Aaronson (2021), Couture and Toupin (2019), Zhang (2025), Hummel et al. (2021)	Data as a sovereign asset, data security law, personal information protection law, cybersecurity law, data localisation, extraterritorial control.	**RQ2: Objective Three**. Frames regulatory and legal conditions shaping data ownership and cross-border sharing.
Output	Institutional theory and geopolitical context	Scott (2014), Chen (2012), Ameyaw - Brobbey (2018), Thorne and Spevack (2017)	National standards, institutional logics, legitimacy, international standardisation, geopolitical diffusion of digital infrastructure.	**RQ3: Objective Four**. Connects domestic institutional structures to international influence.
Process	Operationalisation of digitalisation	Integrated across the four theories	IoT integration; data collection, storage, platform governance; standard setting, organisational responses; regulatory implementation.	**RQ2: Objective Two**. Examines how digitalisation unfolds through technological, organisational and regulatory mechanisms.
Output	Consequences for global logistics	Integrated across the four theories	Adoption patterns, interoperability, market acceptance, parallel ecosystems, alignment with international norms, geopolitical implications.	**RQ3: Objective Four**. Assesses China's influence on global logistics digitalisation.

4 Research Methodology

4.1 Framing the Methodological Approach and Chapter Structure

Chapter Four presents the methodological architecture of the study and explains the philosophical and analytical choices that guided the investigation into China's approach to container digitalisation. The Chapter establishes a research philosophy grounded in social constructivism and interpretivist inquiry, followed by a qualitative design centred on semi-structured interviews and thematic analysis. These choices were aligned with the empirical demands of the study and the research questions defined in Chapter Two. Section 4.2 presents the research philosophy framing the study, Section 4.3 outlines the qualitative design, Section 4.4 details the data collection procedures, and Section 4.5 explains the analytical strategy. Data collection and data analysis are treated as distinct subchapters because the validity of an interpretivist study depends on transparent documentation of how empirical material was gathered, prepared and interpreted. Section 4.6 addresses ethical considerations, and Section 4.7 concludes the Chapter.

The methodology connects directly to the three research questions. The *first research question* evaluates China's approach to the use of track-and-trace technology on shipping containers. This required an interpretive orientation because the relevant strategies are articulated across policy documents, institutional practices and expert perspectives rather than through a single authoritative source, consistent with approaches outlined by Denzin and Lincoln (2018) and Bryman (2016). The *second question* considers Chinese perspectives on data ownership and data sharing in the digitised supply chain. Understanding these perspectives required attention to meaning, context and institutional framing, reflecting principles of interpretivist epistemology described in Creswell and Creswell (2018) and Silverman (2017). The *third research question* is concerned about the potential implications of Chinese smart containers for global supply chain interoperability. This necessitated an inductive analytical process grounded in empirical

material, following procedures for qualitative category formation described by Mayring (2014) and Neuendorf (2017).

The literature review in Chapter Two demonstrated the relevance of container digitalisation within broader supply chain modernisation and outlined China's policy direction regarding IoT applications in maritime logistics. The study also identified four significant gaps. Firstly, existing studies did not offer a comprehensive examination of China's smart container deployment, adoption patterns or contractual arrangements between technology providers, operators and container owners. Secondly, research had not sufficiently addressed the implications of cybersecurity and data governance for smart container operations within the Chinese regulatory environment. Thirdly, while national policies emphasised technological modernisation and domestic innovation, there was no evidence that smart container IoT technologies were explicitly included in associated incentives. Fourthly, no integrated assessment existed regarding how these technologies might influence global interoperability. These gaps required a methodological strategy capable of analysing both formal documentation and expert interpretation.

The methodological design responds to these requirements and draws on established qualitative research traditions. Denzin and Lincoln's (2018) work provided the overarching interpretive framework for understanding meaning in context. Mayring (2014) informed the stepwise, rule bound approach to category development and text analysis. Silverman (2017) contributed principles for ensuring analytic discipline and transparency. Bryman (2016) informed the structuring of the qualitative research process, including sampling and the formulation of interview protocols. Creswell and Creswell (2018) guided the articulation of the philosophical position underpinning the study. Neuendorf (2017) offered guidance on systematic coding practices, and Schiffrin, Tannen and Hamilton (2018) supported the interpretive analysis of interview language and meaning.

Following these methodological foundations, the research design began with clear formulation of the research objectives and questions. Semi-structured interviews were selected to access informed perspectives and to allow the emergence of context dependent insights, in line with the principles set out by Bryman (2016). Initial coding categories were generated deductively from the literature review and theoretical framework and

were subsequently expanded through iterative engagement with the interview transcripts, consistent with Mayring's (2014) approach to inductive category development. The thematic analysis proceeded through repeated cycles of coding, refinement and category consolidation until interpretive stability was achieved.

The remainder of the Chapter outlines the philosophical foundations of the study, explains the rationale for adopting a constructivist ontology and interpretivist epistemology, and details the qualitative research design. The Chapter documents the processes of data collection, coding, analysis and validation to ensure the methodological coherence and transparency of the study.

4.2 Research Philosophy

The study of China's adoption of smart containers, situated within the global supply chain environment and the evolution of digital logistics technologies, required a clear articulation of the philosophical position underpinning this study. Establishing this position was essential because the research questions address institutional meaning, policy interpretation and expert understanding rather than observable technical variables. The philosophical orientation therefore informs the study's assumptions about how reality is constituted, how knowledge can be generated and how the researcher's position influences interpretation.

Research philosophy is understood as a system of assumptions concerning ontology and epistemology, which collectively shape the design and conduct of qualitative inquiry. Saunders et al. (2016) define research philosophy as a framework that clarifies assumptions about the nature of reality, the grounds for knowledge and the role of values within the research process. These assumptions guide all decisions in a qualitative study, including how the research questions are constructed, how data are interpreted and how analytical claims are justified.

The following subsections examine the ontological and epistemological positions adopted in this investigation. This clarification provides a coherent foundation for the methodological approach taken in the study and ensures that the analysis of the smart container phenomenon is aligned with a consistent set of philosophical commitments.

Articulating these assumptions supports methodological transparency and enables the interpretation of expert perspectives on smart container adoption within the Chinese maritime context to rest on clearly defined conceptual grounds.

4.2.1 Research Ontology

Ontological assumptions shape how researchers perceive the nature of the phenomenon under investigation and, consequently, how they design and conduct their studies (Saunders et al., 2016). Research philosophies can be situated along a spectrum between objectivism and subjectivism (Niglas, 2010). From an objectivist position, social entities are viewed as existing independently of human perception, unaffected by interpretation or experience (Burrell & Morgan, 1979). Subjectivism, in contrast, holds that social reality is constructed through the perceptions, actions and interpretations of individuals, implying that reality is shaped by the way people engage with it (Saunders et al., 2016). This ontological distinction directs how phenomena are explored and how evidence is gathered and interpreted.

For the present study, these ontological considerations are fundamental. The study assumes that the meaning and function of the smart container in China cannot be understood as an external or purely technical entity with a fixed, observer-independent status. Instead, the concept must be interpreted as a socially constructed phenomenon whose meaning is shaped through institutional perspectives, industry practices and the specific conditions of adoption, including cost, regulatory boundaries and user expectations. This understanding aligns with the interpretivist and constructivist view that social reality is continuously created and redefined through interaction (Saunders et al., 2016).

The literature review established that the ontological status of the smart container remains fluid. Chapter Two established that neither Chinese policy documents nor international regulatory sources provide a precise or authoritative definition of the smart container, leaving the concept only partially specified within both national and global digitalisation discourse. This ambiguity reinforces the need for an ontological stance that recognises social construction as central to how technologies acquire meaning within organisational and policy environments.

Understanding Chinese smart containers outside their social, institutional and market contexts would be insufficient, because their diffusion is influenced not only by technical capabilities but also by human decision-making, perceived value, policy incentives and broader interpretations within the logistics sector. Interpretivism supports this analytical orientation by asserting that the social world of business is too complex to be examined through methods modelled on the natural sciences (Saunders et al., 2009). Therefore, this view of reality is not pre-given but constructed through experience and interpretation, which shifts the analytical focus from identifying universal causal laws to understanding context-specific meanings (Easterby-Smith et al., 2012).

Interpretivist research further emphasises that individuals, shaped by their backgrounds and experiences, construct reality through ongoing interaction (Wahyuni, 2012). In complex organisational environments such as the Chinese maritime and logistics sector, reducing these dynamics to generalised laws would obscure essential insights. It is therefore necessary for the researcher to recognise and interpret the differences between actors and the meanings they attach to smart container technologies (Saunders et al., 2009). This ontological stance directly informs the methodological choices of the study and supports an analysis centred on expert interpretation, institutional meaning and contextualised understanding.

4.2.2 Constructivist approach

This study adopts a social constructivist orientation because the meaning of the smart container in the Chinese context cannot be reduced to its technical characteristics alone. Its significance is shaped through the perceptions, expectations and interpretations of stakeholders within China's supply chain and maritime domains and therefore, socially constructed rather than technologically determined. The empirical material ought to reflect the views of practitioners from both public and private organisations, whose interpretations are informed by institutional roles, market pressures and policy frameworks, that mediate how digital technologies are framed, legitimised and operationalised. In line with the interpretivist tradition, the research seeks to understand the subjective meanings that participants attribute to the smart container within their social and organisational environments (Creswell & Creswell, 2018; Saunders et al.,

2016), recognising that knowledge about technological adoption emerges through socially situated sense-making rather than objective measurement alone.

Constructivist approach is particularly suited to the research objectives. While the first objective focuses on how track-and-trace technology has been conceptualised in academic literature, the subsequent objectives require examination of how Chinese stakeholders interpret national strategy, organisational priorities and data governance in practice. These interpretations are shaped by institutional context and policy discourse, making a constructivist lens analytically appropriate.

Given this orientation, the research design employs semi-structured interviews as the primary method of data collection. Within a constructivist perspective, interviewing is understood as an interaction through which meaning is actively produced rather than passively extracted, with findings emerging from the dialogical exchange between researcher and participant. Brinkmann (2018) emphasises that interview findings arise through the particular social situation created between interviewer and interviewee, which aligns with the aims of this investigation. This perspective is especially relevant in the Chinese context, where institutional roles and relational dynamics influence how technology adoption is described and justified, and where narratives may reflect both strategic positioning and policy alignment.

The analytical process draws on principles associated with grounded theory to support the development of data driven categories and themes (Charmaz, 2014; Creswell, 2017). The interview guide was structured to elicit both descriptive and interpretive insights, providing an initial framework for coding. During the conversations, participants introduced additional perspectives that were not anticipated at the outset. These emergent insights were incorporated during subsequent rounds of transcript review, resulting in new inductively derived codes. The early stages of analysis therefore relied on open coding to identify patterns grounded in the data, followed by more deductive refinement as categories were consolidated through repeated iterations. This iterative movement between inductive emergence and deductive engagement with existing theory is consistent with a constructivist epistemology, as it recognises that interpretation develops through continuous interaction between empirical material and conceptual understanding. This combination of inductive and deductive logic supports the construction of an

analytically coherent interpretation of how Chinese stakeholders conceptualise and anticipate the development of smart container technologies, while remaining attentive to the institutional and policy contexts that shape these constructions.

4.2.3 Epistemology

Epistemology concerns the nature of knowledge and establishes what is regarded as legitimate within a given research philosophy (Saunders et al., 2016). Within a constructivist epistemology, knowledge is understood as generated through human experience and context specific interaction rather than as a universal or observer independent truth (Eatough & Smith, 2007). This perspective assumes that meaning is co-created through social processes and shaped by the particular environments in which individuals operate. Such an epistemological position aligns with the aims of this study, which seeks to understand how Chinese stakeholders interpret the role, value and implications of smart container technologies within their institutional and organisational contexts.

The knowledge produced in this research is therefore grounded in the interpretive contributions of participants who possess relevant subject matter expertise and direct engagement with digitalisation in China's supply chain sector. The sampling, interviewing and analytical stages reflect this epistemological position, as understanding emerges through interaction between researcher and participants rather than through the pursuit of objective measurement. The researcher's professional and academic experience in supply chain digitalisation enabled informed, contextually sensitive dialogue, which supported deeper exploration of themes such as the origins of the technology, approaches to data sharing, regulatory conditions and the characteristics of state business relations in China.

The interviews were conducted primarily in Chinese to ensure that participants could express their perspectives in the linguistic and cultural context in which their professional experiences were formed. This facilitated clarity, nuance and openness in discussion, thereby strengthening the credibility of the data generated. In three cases, interviewees chose to communicate in English to articulate their views with greater precision, which similarly contributed to maintaining accuracy in meaning. The resulting data therefore

reflect a co-produced body of knowledge shaped through the interaction of linguistic, cultural and professional understandings.

4.3 Research Design

A research design provides the logical structure that links empirical data to the research questions and ensures that the evidence collected can meaningfully address the aims of the study (Yin, 2014). Its purpose is to prevent misalignment between data and inquiry and to ensure that analytical conclusions are grounded in systematically gathered material. The design adopted for this research reflects these requirements and demonstrates how the methodological choices support the investigation of Chinese container digitalisation.

During the planning stage, the researcher evaluated different qualitative strategies and decided against the use of Interpretative Phenomenological Analysis (IPA). IPA, grounded in phenomenology, focuses on exploring how individuals make sense of their lived experiences (Smith et al., 2009). This approach was not appropriate for the present study because the research questions do not centre on personal experience but on institutional, regulatory and technological interpretations within China's supply chain environment. While IPA's commitment to detailed, case-specific meaning-making provides valuable insight in studies of personal experience, it does not align with an investigation whose aim is to map broader patterns of understanding across a diverse group of experts. Furthermore, IPA's emphasis on idiographic depth would limit the comparative, cross-case analysis required here (Ayres et al., 2003). The interpretive component of IPA, often described as a double hermeneutic in which participants interpret their experiences and researchers interpret those interpretations (Giddens, 1986), was not suited to the scope of this research, which required a broader analytic lens.

Instead, the study adopts a design that combines within-case and across-case analysis (Yin, 2018; Miles et al., 2014). Within-case analysis enables each participant's interpretation of smart container development, data governance, and regulatory dynamics in China to be examined in depth, preserving contextual meaning and complexity of lived experience (Kvale & Brinkmann, 2015). Across-case analysis then facilitates systematic comparison, allowing for the identification of recurring themes, divergences, and shared

structures of meaning across interviews (Miles et al., 2014; Charmaz, 2014). This dual approach is particularly relevant for a topic that involves both personal interpretation and institutional context (Yin, 2018).

The use of Chinese language interviews created an additional analytical requirement. The data were examined both in their original Chinese form and through their English translations. This process allowed for cross-checking meanings, ensuring that the analytic interpretation remained faithful to the nuances expressed in the original language and context. Such iterative comparison supported the credibility of the findings and strengthened the accuracy of the thematic development.

4.3.1 Research Method

The research method for this study is grounded in qualitative inquiry and is designed to investigate how Chinese stakeholders interpret the development, use and implications of smart container technologies. Semi-structured interviews were selected as the primary method because the research questions concern subjective interpretation, institutional meaning and context dependent understandings that cannot be captured through quantitative measures. This method aligns with the constructivist and interpretivist foundation established in Section 4.1, where meaning is understood as produced through interaction rather than discovered as an observer independent fact (Creswell & Creswell, 2018; Saunders et al., 2016).

Participants were selected through purposive sampling based on their direct experience with digitalisation processes, maritime logistics operations or policy frameworks related to container technology in China. This ensured that the data reflected informed and relevant viewpoints. As detailed in Section 4.4.2, sampling and recruitment were guided by the requirement to capture perspectives across public, private and hybrid institutional environments, which later shaped the empirical categories presented in Chapters Five and Six.

The interaction between interviewer and interviewees forms an integral part of the research process. The researcher's professional background in supply chain digitalisation facilitated a shared conceptual vocabulary and supported the co construction of meaning during interviews, consistent with the epistemological stance outlined earlier. As

demonstrated in the findings (see Chapter Five, section 5.2), these exchanges in the dialog form were essential to uncovering how interviewees interpreted the purpose of the smart container, its anticipated future development and the constraints governing its adoption.

The analysis incorporates elements associated with grounded theory. Although the study does not aim to construct a full grounded theory, its coding procedures draw on grounded theory principles such as iterative category development, constant comparison and gradual abstraction (Charmaz, 2014). These procedures guided the identification of initial inductive themes, several of which later formed the analytical categories presented in Chapter Five. Early open coding allowed patterns to emerge directly from the interview material, while subsequent rounds introduced more deductive structuring as categories were tested across cases and refined, as per analytical procedures stated in Subsection 4.5 and resulting thematic structures in Chapter Five.

This combination of constructivist interviewing and grounded theory informed analysis created a methodological structure that accommodates both the complexity of the Chinese context and the interpretive nature of the research questions. Subsection 4.4 explains the detailed procedures for data collection, Subsection 4.5 outlines the coding and thematic analysis process, and Chapter Five demonstrates how these methodological choices culminated in the empirical findings that address the study's research questions.

4.3.2 Qualitative Research based on a combined Approach: Grounded Theory Elements with Constructivist Interpretation

The qualitative approach adopted in this study is grounded in the objective of understanding how Chinese stakeholders interpret and construct meaning around smart container technologies. This required an analytical approach capable of capturing subjective understandings, institutional reasoning and context dependent interpretations. Grounded theory elements provided a systematic and iterative structure for coding and category development, while a constructivist orientation, outlined earlier in Section 4.2.2, guided the interpretive dimension of the analysis. This combined approach ensures coherence with the research questions that were first introduced in Chapter Two as part

of the literature review and theoretical framework, where their conceptual basis was established.

Grounded theory originated as an alternative to deductive research traditions and emphasises the generation of analytical categories through systematic coding and repeated engagement with empirical material (Charmaz, 2014). Extensive notes were kept throughout the study supported reflexive engagement with emerging ideas and provided transparency regarding the evolution of analytical decisions (Oliver, 2012). These notes later informed the analytical narrative presented in Chapter Five.

The empirical foundation of the study consists of semi-structured interviews, complemented by observations and documentary sources. The interview guide was developed during the pilot stage and consisted of a set of open background questions followed by ten core questions. These addressed organisational approaches to container digitalisation, perceived use cases of smart containers, reactions to the German shipping line's full fleet digitalisation approach, the technologies used for digitalisation, provider selection and country of origin considerations, the use and sharing of data, participation in standardisation activities, national technological priorities and perceptions of government subsidisation. These themes were selected to elicit expert interpretations relevant to the research questions and later served as the empirical basis for the thematic structure presented in Chapter Five.

The analytical process combined inductive and deductive reasoning. Inductive reasoning facilitated the identification of themes that were not predetermined by the theoretical framework. Deductive reasoning ensured that emerging interpretations remained aligned with the research questions defined in Chapter Two. This dual logic proved particularly valuable for a phenomenon such as the smart container, which is embedded in broader institutional, regulatory and market dynamics.

The coding procedure, described in detail in Section 4.5.2, followed three stages commonly associated with grounded theory. Open coding was used to identify short, meaningful units of text. Examples include participants describing the smart container as part of a broader national digital infrastructure, expressing concerns about device cost or emphasising the need for data to remain within Chinese jurisdiction. Axial coding

regrouped these initial codes by identifying connections between them. Codes concerning subsidy structures and expected return on investment formed the basis of the category addressing economic boundaries of adoption, discussed in Section 5.3. Codes relating to data ownership, server location and institutional sensitivities formed categories concerning data governance and political framing. Selective coding then identified a central integrating concept that linked the axial categories into a coherent account. This integrating concept, elaborated in Chapter Five, interprets smart container development in China as a state aligned digital infrastructure initiative shaped by economic and political constraints.

Constructivist interpretation shaped the understanding and reporting of these categories. Analysis focused on how interviewees explained the meaning of smart containers in relation to their organisational roles and regulatory environments, consistent with the view that meaning making is socially situated (Schwandt, 1994). Contextual interpretation was essential for understanding statements concerning technology preferences, data localisation and the role of national direction. Reflexive practice, following Finlay (2002), ensured that the researcher's professional and linguistic proximity to participants did not overshadow participant viewpoints. Reflexive notes documented moments where interpretations risked being researcher driven rather than grounded in the empirical material.

Constant comparative analysis provided additional analytical discipline. New data and emerging categories were systematically compared with earlier interpretations to ensure conceptual coherence. This process led to refinements such as the differentiation between central and provincial influences on adoption, discussed in Chapter Five. Such iterative comparison ensured that the resulting theory remained grounded in the data rather than guided by prior assumptions.

The final phase involved theory building, understood here as the development of an interpretive explanation of how Chinese experts conceptualise smart container adoption. The theoretical contribution presented in Chapter Six conceptualises adoption not as a purely technical decision but as a socially constructed institutional process shaped by national digitalisation goals, economic rationality and data governance requirements. As Charmaz (2006) notes, constructivist grounded theory relies on abduction to interrogate

unexpected findings. This study made use of abductive and retroductive reasoning, as described by Oliver (2012), particularly in the analysis of politically sensitive topics such as state-business relations and digital data control. Asking what conditions should be present for certain interpretations to emerge strengthened the explanation developed in the findings.

The methodological approach outlined in this section, in combination with the data collection procedures in Section 4.4 and the analytical steps detailed in Section 4.5, provides the foundation for the empirical findings presented in Chapter Five.

4.3.3 Semi-structured interviews

Easterby-Smith et al. (2012) identify a wide range of qualitative data collection approaches, noting that many lack definitional precision. They classify data gathered from organisational actors as natural language data, since it relies on respondents' own accounts to illuminate social and organisational realities. Interviews remain the central technique for collecting such data, supplemented but not replaced by documentary analysis, observation, or the examination of physical artefacts (Yin, 2018). For this study, this distinction matters. The research examines strategic intent, policy reasoning, and operational decision making in a context where formal documentation is either limited, rhetorical, or politically curated. Natural language data therefore provides the only viable route to uncovering the assumptions and tensions that shape practice.

Wahyuni (2012) similarly argues that studies investigating specific organisational practices depend on primary data collected through semi-structured interviews with experts. Yin (2014) goes further by demonstrating that interviews can constitute the sole evidence base for entire research designs. This is not a methodological convenience, but rather a reflection on how much of the decision-making surrounding container digitalisation, data governance, and national strategic imperatives is neither public nor systematically documented. Without interviews, the drivers of China's approach and the perceptions of international actors would remain inaccessible. The method is therefore not only justified but required to address the research questions.

Interviews are commonly categorised into structured, semi-structured, and unstructured formats (Saunders et al., 2009). Semi-structured interviews employ a predetermined set

of themes, while allowing flexibility in the order and depth of questioning as the conversation progresses. For this research, the choice of a semi-structured format was deliberate and necessary. A structured interview would have restricted respondents to superficial and rehearsed narratives, while an unstructured approach would have undermined comparability across participants and countries. The semi-structured format ensured consistency in the analytical domains covered, while enabling respondents to introduce context specific insights, contradictions, or sensitive issues that were essential for understanding the interplay between technology, policy, and institutional incentives.

Wahyuni (2012) and Noor (2008) highlight that semi-structured interviews permit the researcher to adapt questions to the expertise of each respondent while maintaining coherence in data coverage. Taylor and Jack (2016) note that this format is particularly effective for eliciting how and why explanations. This capability was central to the study. The research required not only descriptive accounts of what organisations claim to do but an examination of the reasoning that underpins their choices, including the influence of political priorities, risk assessments, and commercial dependencies. Semi-structured interviews therefore provided the methodological precision needed to reveal the mechanisms and contradictions that define China's smart container strategy and its implications for global logistics governance.

Table 4.1: Comparison among Research and Interview Questions with Research Objectives

Research Objective	Research Question	Interview Question
RO1: is to identify, through a critical review of the academic literature, how track-and-trace technology has been conceptualised and adopted within Chinese container maritime transportation.	**RQ1:** What is the Chinese approach towards using track-and-trace technology for shipping containers?	What is the main use case of "smart" containers for you? What is your opinion on German approach to have each container trackable using an IoT device?

RO2: to analyse empirically the Chinese approach to using track-and-trace technology on Chinese-owned containers operating in global logistics.	**RQ1:** What is the Chinese approach towards using track-and-trace technology for shipping containers? **RQ3:** What is the potential influence of Chinese smart containers on the global logistics system?	What is your company's approach to digitalization of containers? What are the main technological interests of the national committee? Which standardisation bodies do you and your company participate in, and why?
RO3: to evaluate from the qualitative study the Chinese perspective on data ownership and sharing in digitized supply chain.	**RQ3**: What is the Chinese perspective on data ownership and sharing in the digitised supply chain?	How do you use the data collected by the "smart" container? What plans does your organisation have to share data with freight forwarders? Port authorities? Beneficial cargo owners?
RO4: to interpret the empirical findings within the context of China's industrial policy goals, to clarify how *Made in China* strategies shape container digitalisation.	**RQ3:** What is the potential influence of Chinese smart containers on the global logistics system?	In your opinion, to what extent is digitalization subsidized by your government?

4.3.4 Thematic qualitative text analysis

This study applied thematic qualitative text analysis to examine the interview data and derive insights related to the central themes of the research, namely Chinese strategy for

container digitalisation and data governance strategies within the context of Chinese smart container adoption. Whereas quantitative analysis reduces data to numerical categories for statistical treatment, qualitative analysis centres on the systematic interpretation and organisation of verbal material (Kuckartz, 2016). Given that the research questions concern institutional reasoning, regulatory interpretation, and strategic behaviour rather than measurable frequencies, a qualitative approach was required.

Thematic analysis is one of the most widely recognised techniques for analysing interview content (Neuendorf, 2019). The strategy involves segmenting interview transcripts into analytically meaningful units and repeatedly interrogating these units to identify underlying meanings (Vaismoradi & Snelgrove, 2019). The method requires identifying, coding, and interpreting patterns that capture explicit statements as well as latent assumptions (Braun & Clarke, 2006). Codes function as analytic placeholders that summarise and organise data for deeper interpretation (Guest et al., 2012). The value of thematic analysis lies in its capacity to accommodate both overt and subtle content (Vaismoradi & Snelgrove, 2019). Its main risk, as noted by Braun and Clarke (2006), is superficiality when researchers use interview questions as themes rather than deriving themes from the dataset.

This study addressed this limitation by combining deductive and inductive coding. Although Braun and Clarke (2019) critique Guest et al. (2012) for privileging procedural coding frameworks over interpretivist reflexivity, these positions are not mutually exclusive. Deductive structure ensured analytical discipline and alignment with the research questions, while inductive analysis enabled the identification of unanticipated patterns and culturally specific meanings. This hybrid approach allowed the analysis to capture what Braun and Clarke (2019) describe as “stories about particular patterns of shared meaning across the dataset” while retaining the transparency and traceability of more structured coding procedures.

The analysis followed the process articulated in the Data Analysis section 4.5 and drew on established methodological guidance (see Table 4.4, p.130). The first step involved preparing the transcribed interviews. Since Zoom’s automated transcription introduced errors in Chinese segments, transcriptions were manually corrected and reorganised to

ensure clarity and consistency. This step was essential for maintaining linguistic accuracy and preventing coding distortion.

The second step involved an initial reading of the entire dataset to identify broad patterns and points of convergence. This follows Bryman (2016), who argues that qualitative analysis begins with attentive immersion in the data to familiarise the researcher with its full texture and variability. This preliminary reading revealed early areas of agreement among participants, for example, the distinction between passive tag-based tracking and more advanced IoT-enabled sensors, or shared views on the appropriate level of state involvement in digitalisation initiatives.

The third step was the development of initial codes, drawing on Denzin and Lincoln's (2018) recommendation that coding should connect empirical material to the core analytical concerns of the study. At this stage, structured codes such as "background," "data sharing," "subsidies," "technology selection," and "regulatory alignment" were created. Although these categories were informed by the research questions, they were validated and refined through iterative comparison with the dataset to avoid imposing external assumptions onto the material.

In the fourth step, the initial codes were consolidated into broader themes, following Creswell and Creswell's (2018) guidance on theme construction. These overarching themes (see Table 3.1) captured cross-cutting issues such as strategic motivations, perceived risks, regulatory constraints, and interpretations of data sovereignty. The themes were then developed into descriptive and interpretive narratives, as suggested by Bryman (2016), integrating theoretical perspectives with participant accounts.

A pilot coding exercise was conducted prior to the full analysis. This involved constructing a preliminary code tree, applying it to a subset of interviews, and revising the coding structure to address inconsistencies, redundancies, and conceptual gaps. This process strengthened the reliability of the coding scheme and exposed weaknesses in early categorisation that would otherwise compromise the full analysis.

The final coding and thematic consolidation were conducted in both English and Chinese using NVivo and Atlas.ti (selected insights are captured in Appendix IV). Two rounds of coding were completed to ensure stability and consistency across languages and to

mitigate potential bias arising from translation. NVivo facilitated systematic data organisation, supported pattern recognition, and ensured an auditable analytic trail. For the intercoder reliability exercise on the Chinese transcripts, Atlas.ti was used to compare coding between the principal researcher and the Chinese native speaker, Ms YinYing Kong. The software's side by side comparison functions provided a transparent assessment of coding convergence and divergence, thereby strengthening the credibility of the Chinese language analysis.

Overall, the thematic analysis proceeded through an iterative, structured, and reflexive process that sought to balance methodological discipline with openness to emergent patterns. This ensured that the final themes were both grounded in the empirical material and analytically coherent, thereby supporting credible and rigorous answers to the research questions.

4.4 Data Collection

4.4.1 Introduction

China occupies a central position in global containerisation. The country manufactures more than ninety-five per cent of the world's dry freight containers (UNCTAD, 2023) and hosts six of the ten busiest container ports (World Bank S&P Global Market Intelligence, 2023). Although the world's largest container ship operators are MSC and Maersk, China remains one of the most significant operators through COSCO Shipping, which ranks fourth globally (Alphaliner, 2024). As the research examined China's strategic approach to container digitalisation, including data ownership and data sharing, it required direct engagement with actors who shape these decisions. The data collection strategy therefore focused on obtaining accounts from individuals positioned within the regulatory, industrial, and technological structures relevant to the research questions. This ensured that the interviews addressed not only operational details but also underlying institutional logics.

Semi-structured interviews were conducted with representatives from a major shipping line, a container manufacturer, an IoT service provider, a national standardisation body, a government actor, and a freight forwarder or container operator (Table 4.2, p.111). This

sample was not selected for diversity alone but because these actors collectively form the institutional architecture through which China's digitalisation policies are interpreted, operationalised, and contested. Their perspectives were required to answer the research questions, excluding any of these categories would have produced an incomplete or distorted account of the mechanisms under investigation. Interviews were conducted primarily in Chinese because the concepts central to the study, particularly those relating to governance, regulation, and strategic intent, are embedded in Chinese institutional vocabulary that could not be reliably elicited in English. Using Chinese reduced interpretive loss and allowed participants to articulate policy constructs in their own terms, which directly strengthened the validity of the data. The interview design followed Miller and Glassner's (2004) reflection that qualitative interviewing oscillates between representing lived reality and co-constructing meaning. This stance was essential given the study's focus on data governance within a system where political narratives, institutional expectations, and professional hierarchies all influence how information is presented. The way actors construct and communicate their roles, constraints, and expectations provides direct evidence of the institutional logics underpinning digitalisation. Without examining these narrative forms, the drivers of China's smart container strategy would remain only partially understood. Trust and access were established through clear communication, consent documentation, and careful framing of the research purpose.

Semi-structured interviews were selected because alternative formats would have undermined the study's analytical requirements. A structured format would have restricted participants to pre-established categories, making it impossible to capture the implicit rationales and contradictions that are central to the research questions. An unstructured format would have weakened comparability across actors who operate under very different institutional mandates. Semi-structured interviews provided the necessary balance: a consistent analytical frame combined with enough flexibility to elicit unanticipated perspectives, political sensitivities, or operational tensions.

Interviews were conducted via Zoom and lasted between sixty and ninety minutes. The format supported real time interaction, observation of nonverbal cues, and accurate recording. The interview process followed Holstein and Gubrium's (2004) guidance on managing interactional bias, focusing on question clarity, avoidance of leading

formulations, and allowing participants space to elaborate. These choices were essential because the study examines phenomena where responses are shaped not only by individual knowledge but also by institutional pressures and political context. The interviewer therefore assumed responsibility for interpreting subjective accounts while recognising the structural factors shaping them.

In summary, the data collection design was driven by the analytical needs of the study. Each methodological decision responded to a specific challenge inherent in researching Chinese digitalisation policy: linguistic complexity, restricted documentation, institutional incentives for conformity, and the political sensitivity of data ownership and data sharing. The resulting interview dataset provided access to reasoning, contradictions, and strategic interpretations that cannot be obtained through secondary sources alone.

4.4.2 Sampling

The sampling strategy was designed to generate data that could meaningfully address the research questions rather than to achieve numerical representativeness. As the study incorporated elements of grounded theory, the concept of saturation guided the process of selecting participants. Glaser and Strauss (1967) describe saturation as the point at which further data collection no longer contributes new theoretical insights. This definition emphasises an iterative process in which coding, analysis and subsequent sampling occur consecutively. Nelson (2017) argues that decisions regarding further sampling can only be made after initial analysis has begun, since the emerging categories indicate where additional evidence may be required. Charmaz (2014) further explains that saturation is achieved when analytical categories are conceptually robust, meaning that no new properties appear and that existing ones adequately account for variation within the data.

Guest et al. (2006, 2020) noted that saturation is frequently misinterpreted as a simple numerical criterion for determining sample size. The literature provides no fixed rule, and qualitative studies vary considerably. Phenomenological research, for example, may involve between five and twenty-five interviews (Morse, 1994). For this study, the central issue was not the numerical range reported in the literature, but the number of interviews

required to achieve analytical depth in the categories relevant to the research questions, particularly those concerning data governance. Charmaz's (2014) caution that saturation should not be equated with the impression that nothing new is being said was taken seriously. Saturation was interpreted as the point at which categories demonstrated conceptual density rather than mere repetition.

The research required a sample drawn from a clearly defined industry context. Participants therefore needed to operate within the maritime or intermodal container sector, speak the same language and share a broadly similar institutional environment. A purposive and relatively homogeneous sample was appropriate because the study sought to identify shared institutional logics and sector specific reasoning rather than to compare divergent populations. The pool of potential participants with direct operational knowledge of smart container development and data governance within the Chinese context is inherently limited. Expertise in this area is concentrated among a relatively small number of senior managers, technical specialists and policy-affiliated actors. Access to such individuals was further constrained by the political and commercial sensitivity surrounding digitalisation strategies, particularly where smart container initiatives intersect with state-supported industrial policy and international competitiveness. Several prospective participants declined involvement or restricted the scope of discussion due to concerns about confidentiality and the disclosure of corporate or potentially state-aligned strategic priorities. These structural constraints necessarily shaped the achievable sample size. Therefore, the sample was designed to capture insights from actors directly involved in different stages of the smart container ecosystem. The selection therefore included representatives from five relevant stakeholder groups within the container digitalisation landscape. These groups comprised shipping lines and container owners responsible for operational deployment of container fleets, container manufacturers involved in the technological integration of digital devices into equipment, IoT technology providers developing tracking solutions, leasing companies that control a significant share of the global container fleet, and governmental or standardisation institutions shaping regulatory and strategic frameworks for logistics digitalisation. Interviewees were selected based on their professional experience, their organisational role, and their direct involvement in initiatives related to container digitalisation, smart container development, or related standardisation activities.

The resulting sample reflects a cross-sectional view of the Chinese smart container ecosystem, combining perspectives from industry operations, technology development, manufacturing, commercial asset management, and state level policy and research institutions. Such diversity of viewpoints was considered essential for understanding not only the technological dimension of smart containers but also the strategic, institutional, and governance attributes that influence their adoption. This sampling logic allowed the study to capture the interaction between commercial actors, technology providers, and state institutions that collectively shape the trajectory of container digitalisation in China (Table 4.2).

In total, eight interviews were conducted with individuals who met these criteria**.** After the first five interviews, all initial codes had been generated and subsequent interviews confirmed existing patterns rather than introducing new categories. The final three interviews produced greater nuance and elaboration but did not generate substantively new thematic domains, indicating increasing conceptual density rather than category expansion. This outcome is consistent with consensus theory, which suggests that individuals working within the same domain frequently share common interpretations (Romney et al., 1986). This finding also supports the observations of Guest et al. (2006) and Yin (2014), who report that most novel themes in semi-structured interviews tend to emerge within the first six to ten interviews.

Nelson (2017) highlights an inherent difficulty in the concept of saturation, particularly the misleading implication of completeness. In response to this concern, this research adopted conceptual density and depth as the operational indicators guiding sampling decisions. Saturation was therefore assessed not in terms of numerical sufficiency alone, but through iterative comparison of emerging codes across interviews, monitoring whether additional data altered the structure of the coding framework or merely reinforced established interpretive patterns. Transparency and methodological clarity were maintained throughout the process. Following the recommendations of Kerr et al. (2010), a detailed codebook (Table 4.3, p. 123) was developed that contained concise and extended definitions for each code, criteria for their application and illustrative quotations drawn directly from the data. For quality assurance, interviews conducted in Chinese were analysed twice, first in the original language and subsequently in English, to mitigate risks associated with translation loss and to ensure stability across coding rounds.

Participants were selected based on their expertise within maritime or intermodal container transportation and, specifically, their experience within the Chinese industry. This ensured that the sample could provide evidence relevant to the institutional, regulatory and technological environment under investigation. All participants received a consent form prior to the interview. Although several participants indicated that they were comfortable with their names and professional positions being known to the public, personal or organisational identifiers were not disclosed in the study. All interview data were anonymised irrespective of individual preference, and interviews were conducted by video call with recording permitted only when explicitly approved. Given the political sensitivity of digital infrastructure and data governance in China's logistics sector, this strict anonymisation protocol was essential to facilitate candid discussion and to minimise risks to participants.

Table 4.2: Interviewees Profiles

Interviewee	Organisation	Role in the Organisation	Why Selected	Justification for Inclusion in the Sample	Researcher Expectations
Interviewee 1	Chinese Shipping Line	Container Steering (Reefer Operations)	Leading Chinese container owner deploying IoT devices	Selected to represent the operational perspective of a major Chinese shipping line directly involved in container fleet management and early smart container deployment. Provides practical insights into implementation challenges, operational benefits, and data usage.	General vision on smart containers and data sharing practices
Interviewee 2	Former Chinese Container Manufacturer Intelligent & Security Centre	Former General Manager	Chinese Container Manufacturer is the world's largest container manufacturer and an early developer of smart container concepts	Included to provide a manufacturing and technology development perspective. Their experience in intelligent container initiatives offers insight into Chinese technological capabilities and industrial strategies behind smart container development.	Definition of the smart container and view on IoT deployment made in China

Interviewee	Organisation	Role in the Organisation	Why Selected	Justification for Inclusion in the Sample	Researcher Expectations
Interviewee 3	Chinese IoT service provider	CEO	Chinese IoT company supplying container tracking devices	Selected to represent the perspective of a Chinese technology provider developing IoT solutions for container fleets. This interviewee provides insight into device architecture, business models, and technological competition between Chinese and international IoT providers.	Competitive analysis of IoT technology in China versus global competitors
Interviewee 4	Chinese Container Manufacturer	Industry Expert	Chinese Container Manufacturer is the global leading container manufacturer	Included to capture the container manufacturing industry perspective, to provide insight into industry views on IoT integration into container production.	Industry perspective on smart container technologies
Interviewee 5	Standardisation Administration of China (SAC)	Researcher, National Committee Representative	Active leader in Chinese standardisation activities related to smart containers	Selected to represent the standardisation and policy dimension of container digitalisation. Their involvement in national and international standards development	Definition of smart containers and perspective on

Interviewee	Organisation	Role in the Organisation	Why Selected	Justification for Inclusion in the Sample	Researcher Expectations
				provides insight into China's strategic engagement with global standards bodies.	international standardisation
Interviewee 6	Former Chinese Container Leasing Company	Former senior industry professional	Over 30 years of experience in container leasing and operations	Included to represent the leasing sector, which controls a significant share of the global container fleet. Provides insights into commercial decision-making and the economic rationale for or against smart container adoption.	Smart container deployment perspectives from leasing companies
Interviewee 7	China Waterborne Transport Research Institute / Ministry of Transport	Government representative	Directly involved in national research on smart container technologies	Selected to represent the governmental and research policy perspective. Provides insight into the Chinese state approach to logistics digitalisation, data governance, and strategic priorities for container tracking technologies.	State approach to smart containers and data ownership

Interviewee	Organisation	Role in the Organisation	Why Selected	Justification for Inclusion in the Sample	Researcher Expectations
Interviewee 8	Chinese Container Manufacturer	General Manager of one of the Divisions	Senior executive in container manufacturing and leasing	Included to capture insights from the manufacturing and leasing interface. Provides perspective on industry incentives, technological feasibility, and commercial barriers to large-scale smart container adoption.	Manufacturing and leasing perspectives on smart container deployment

4.4.3 Data Collection: Interview Protocol and Interview Guide

Semi-structured interviews were adopted as the principal method of data collection because the research questions require an understanding of how Chinese industry actors interpret and make sense of container digitalisation. These interpretations concern technical decisions, organisational reasoning and institutional expectations that cannot be captured through documentation or quantitative data. Semi-structured interviews therefore provided the appropriate methodological approach for generating the depth and nuance required for this study.

Participants were drawn from organisations directly engaged in the engineering, operational deployment and regulatory framing of IoT track-and-trace solutions for intermodal containers. This included senior technical specialists, operational managers within major Chinese shipping companies and individuals involved in national standardisation processes. Such actors are often difficult to access, and consistent with Bryman's (2016) observation that qualitative research in specialised fields is shaped by gatekeeping, the researcher used professional networks associated with the United Nations and the International Organization for Standardization to identify potential participants. The purpose of sampling was to secure rich and analytically relevant accounts rather than to achieve numerical breadth. In line with Bell, Bryman and Harley's (2022) guidance that qualitative depth takes precedence over volume, the final set of interviews remained limited but provided the necessary conceptual richness.

Interviews were conducted on a one-to-one basis to encourage participants to articulate their perceptions, constraints and reasoning without the pressures that accompany group settings. Brinkmann (2018) notes that qualitative interviewing aims to reveal how individuals construct meaning around the phenomenon under investigation, which requires an interview environment that supports personal reflection and openness. An interview guide was prepared following Bryman's (2016) approach and consisted of open questions organised into thematic areas related to smart containers, data, technology and standardisation. This structure allowed comparability across interviews while maintaining flexibility. Clark et al. (2021) emphasise that semi-structured designs permit a meaningful balance between consistency and responsiveness to the participant's own framing, which is essential for producing analytically robust material.

The interviews encouraged extended responses that often moved across thematic boundaries. Discussions of technology frequently led into issues of standardisation, and questions concerning data prompted reflections on organisational policy or institutional pressure. Brinkmann (2018) argues that insights emerging beyond the original structure of an interview are often critical for understanding the deeper meaning of participants' accounts. The interviewer therefore allowed time for elaboration and used probing questions when new themes emerged. Several participants chose to be interviewed in Chinese, and this option was important because many concepts in Chinese digitalisation discourse and institutional language cannot be translated into English with precision. Conducting interviews in the mother tongue strengthened the validity of the data by allowing participants to express reasoning embedded in cultural and linguistic context. Although some interviewees indicated that they were comfortable being identified, all interview data were anonymised and recordings were made only when explicitly approved, in accordance with the ethical requirements of the study. This approach ensured that participants could speak openly about institutional practices and regulatory expectations without concern for organisational repercussions, which was essential for generating candid and analytically valuable accounts.

The analysis of the interview responses followed Holstein and Gubrium's (2004) view that interviews are interactional events in which meaning is co-produced rather than simply transferred. This aligns with the constructionist sensibilities articulated by Berger and Luckmann (1967), who argue that knowledge is shaped by the social context in which it is generated. Therefore, the analysis paid attention not only to the content of participants' statements but also to the way in which they constructed their accounts, including the narrative strategies and cultural assumptions underpinning their responses. Baker (2004) proposes that interview responses should be treated as accounts rather than reports, since accounts reveal the interpretive frameworks through which individuals justify and organise their understanding. Pre-selected and subsequently refined categories were used to organise the transcripts, consistent with Baker's recommendation that categorisation assists in analysing both meaning and meaning making.

Interviews functioned as social and interpretive encounters in which both interviewer and interviewee contributed to the generation of knowledge. Participants drew on cultural codes, professional norms and institutional expectations when articulating their

understanding of container digitalisation and data governance. Recognising these elements as intrinsic to the data allowed the study to capture not only what participants believe but how these beliefs are formed, justified and situated. Overall, the semi-structured interviews provided the empirical foundation required for examining how technical, organisational and institutional factors converge in China's approach to smart container development. The method generated insight into the reasoning, priorities and constraints that structure the system under investigation, which was essential for answering the research questions.

4.5 Data Analysis Method

4.5.1 Overview of the Method

The categorisation of the interview data followed the analytical structure proposed by Baker (2004). Initial codes were organised around major categories derived from the literature review, including smart containers, technology origin, data governance and standardisation. Using these deductive categories ensured that the analysis remained aligned with established research and addressed the theoretical domains central to the research questions. As coding progressed, additional subcategories emerged from the data itself. This inductive expansion was essential because the existing literature does not fully capture the ways in which Chinese actors conceptualise digitalisation and data governance. The combination of deductive and inductive coding therefore strengthened the analytical depth of the study by ensuring that it remained theoretically grounded but sensitive to culturally specific and context dependent meanings that could not be anticipated a priori.

NVivo and Atlas.ti software were used to support this coding process, providing an organised and auditable structure for data management, as recommended by Bazeley and Jackson (2013). The iterative coding procedure followed the principles of grounded theory, including coding, constant comparison and analytical refinement, consistent with Charmaz's (2014) approach. This iterative movement from initial codes toward more abstract themes ensured that the analysis captured both descriptive detail and interpretive patterns across interviews. Thematic analysis offered the overarching framework for identifying these patterns, in line with Braun and Clarke's (2006) guidelines, while the

broader analytical logic drew on Denzin and Lincoln's (2018) interpretive strategies and the systematic organisation outlined by Bryman (2016) and Kuckartz (2014).

Analytical memos were written throughout the coding process, following Clark et al. (2021). These memos documented interpretive decisions, emerging ideas and conceptual links, which made the analytical trajectory transparent and enabled the researcher to track how interpretations evolved over time. The use of memos therefore strengthened the reflexive component of the analysis and contributed to the rigour of the study by ensuring that interpretive steps were recorded and could be revisited, rather than remaining implicit or intuitive. In qualitative research, this transparency is essential for demonstrating the credibility of the findings. Reflective notes therefore served both as a record of analytical reasoning and as a tool for examining how interpretive assumptions developed during the research process, which is central to maintaining reflexive awareness in a constructionist study.

Once coded, the verbal data were organised into themes that reflected recurring patterns across interviews. In line with Kuckartz's (2014) recommendation, structuring the transcripts produced a case-oriented perspective, allowing the analysis to examine how individual accounts relate to broader institutional or technological developments. The combined deductive and inductive approach increased the analytical complexity of the study and enabled the identification of themes that were simultaneously grounded in the literature and shaped by the empirical realities described by participants. Repeated cycles of coding produced different interpretive angles, which enhanced the depth and stability of the thematic structure.

The coding approach incorporated principles from Bryman (2016) and Guest et al. (2012), ensuring that categories were mutually exclusive, consistently applied and capable of capturing all relevant data. A predefined codebook guided this process, following Braun and Clarke's (2019) emphasis on structured and transparent coding. Braun and Clarke also highlight the active role of the researcher in producing knowledge through thematic analysis. This requirement for reflexive awareness informed the analytical process, ensuring that themes were created through critical engagement with the data rather than being assumed to emerge automatically. This position reflects the constructivist dimension of Braun and Clarke's (2019) model and was particularly relevant to this study

because interview responses were shaped by the institutional, cultural and political context of contemporary China. The coding process therefore enabled the analysis to move beyond surface level description and to consider the interpretive logics through which actors framed container digitalisation.

As patterns became clear, they were integrated into a theoretical interpretation that reflects the findings within the broader context of existing literature. This follows the principles of grounded theory, where substantive theory develops directly from data (Glaser & Strauss, 1967). To ensure analytical rigour, the study employed strategies recommended by Lincoln and Guba (1985), including triangulation, member checking and the use of rich, thick description. Reflexivity was maintained throughout to mitigate potential researcher bias. Data triangulation complemented the interview material by drawing on academic literature and industry media sources, which contextualised and strengthened the findings.

The overall analytical approach therefore combined grounded theory procedures with thematic analysis within a constructivist orientation. This combination produced an interpretation that was both theoretically informed and empirically grounded, ensuring that the findings meaningfully reflect how Chinese actors understand and enact container digitalisation and data governance.

4.5.2 Coding the Data

Coding was central to elevating the analysis from descriptive accounts toward theoretical interpretation. As Charmaz (2006) and Grodal, Anteby and Holm (2020) noted, categorisation enables researchers to move beyond surface statements and identify patterns, relationships and conceptual insights within the data. However, Linneberg and Korsgaard (2019) caution that purely inductive coding risks dispersing analytical focus, particularly in studies that address complex organisational or institutional environments. They argue for a structured deductive frame that can guide and discipline the subsequent inductive expansion of codes. In this study, such a deductive coding framework was developed from the research questions and the analytical categories introduced in the earlier research methodology Chapter Four and this framework then shaped and stabilised the inductive coding that followed.

The coding process was informed by the terminology defined by Guest et al. (2012) and the codebook principles outlined by Mayring (2000). These definitions shaped both the design and the execution of the analytical protocol. Firstly, the data consisted of the textual transcripts of eight in-depth semi-structured interviews, prepared in both Chinese and English. These transcripts formed the foundation for all subsequent coding and were treated as the textual representation of the interaction under study, in line with the data collection procedures described in the preceding Subchapter 4.4.

Secondly, a theme was understood as a unit of meaning identified in the data. The interview guide was organised into the thematic areas of introduction, smart container trends, technology, data and standardisation. These themes structured the inquiry during data collection and subsequently provided the initial analytical orientation during coding. This thematic structure followed directly from the interview design explained earlier in the research methodology Subchapter 4.3.

Thirdly, a code was defined as a textual descriptor delineating the semantic boundaries of a theme or subcomponent. Codes were initially derived from the interview questions and then refined through examination of participants' responses. As each transcript was analysed, the coding structure evolved to incorporate new distinctions, tensions or interpretive categories expressed by participants. This iterative refinement reflected the understanding of interviews as co constructed encounters that was outlined previously in the discussion of semi-structured interviews Subchapters 4.3.3 and 4.4.3.

Fourthly, the codebook served as the systematic record of all codes and their characteristics. Consistent with Mayring (2000), the codebook specified the main categories, their definitions, rules for assigning a segment to a category and anchor examples drawn directly from the transcripts. These features ensured that coding remained consistent, transparent and theoretically grounded. The inclusion of examples was particularly important for recognising recurring patterns and supporting the reliability of category assignment.

Fifthly, coding itself was the process of attaching the appropriate code to specific segments of text. Sixth, a text segment was defined as the smallest coherent unit of meaning in the transcript that addressed a specific question, follow-up probe or emergent

topic. In this study, text segments were taken from both the Chinese and English transcripts to ensure that coding was sensitive to cultural nuance and linguistic context. This bilingual approach to text segments was consistent with the earlier decision to conduct interviews in both Chinese and English to preserve linguistic precision.

As Guest et al. (2012) and Gibson and Brown (2009) emphasised, qualitative coding must be conducted with attention to the context in which interviewees narrate. The meaning of a statement is inseparable from the organisational, cultural and institutional circumstances that shape it. This principle was central to the development of the codebook. The initial deductive categories were derived from the research questions, the underlying constructs in the literature and the problem areas identified during the systematic review (Miles & Huberman, 1994), which were presented in the earlier discussion of the research strategy and literature review. Structural coding created an explicit link between data collection and evidence generation by identifying where the design of the study-imposed structure and where participants introduced novel or contested meanings (Guest et al., 2012). In practice, the coding process involved noting the recurrence of key words, metaphors and concepts across interviews and analysing how these were used within participants' accounts of container digitalisation.

The study adopted Guest et al.'s (2012) structure for defining each code, including a concise code name, a short definition, a full definition clarifying theoretical or cultural dimensions, and explicit guidance on when and when not to apply the code. This approach ensured that coding was both systematic and reflexive, allowing the analysis to develop a coherent set of analytical categories that were simultaneously grounded in the literature and in the empirical accounts of Chinese actors. The use of reflexive notes during coding also operated in line with the broader ethical and methodological principles on researcher reflexivity that were discussed earlier in the methodology Section 4.4.

The coding procedure therefore established the analytical foundation of the study by linking the research questions, the key analytical categories derived from the literature review, such as approach to smart containers, IoT technology origin, data governance and the involvement in the standardisation efforts. The combination of deductive structuring and inductive refinement ensured that the analysis remained theoretically anchored while still responsive to the culturally and institutionally specific meanings expressed by

Chinese industry actors. This balance was essential in a context where digitalisation and data governance discourse is shaped not only by technical practice but also by regulatory, political and organisational expectations. Through the systematic development of a codebook and the application of coding rules consistent with established qualitative standards, the study produced a stable and transparent analytical framework capable of supporting subsequent thematic interpretation.

Given the centrality of coding to the overall analytical logic, it was necessary to assess the consistency and reliability of the coding structure, particularly because the data existed in both Chinese and English and contained culturally embedded concepts that required careful interpretation. Ensuring that the coding framework operated consistently across languages and across coders was therefore essential for demonstrating the credibility of the findings and preventing interpretive drift. The following subsection addresses this requirement by outlining the procedures used to establish intercoder reliability and the steps taken to confirm that the analytical structure remained coherent, stable and replicable across the dataset.

Table 4.3: Codebook based on Mayring (2000)

Category	Definition	Rules of Assignment	Anchor Examples	Coding Instructions
approach to digitalisation of containers	Under which conditions containers should be digitised and which technology counts	When interviewee speaks about any applicable track-and-trace or condition monitoring technology	"on client's demand", "QR/RFID tags", "e-seals", "IoT", "sensor"	Code any mentions on smart container and related technology (deployed, denied, in development)
full fleet or fleet within a fleet	Approach towards digitalisation: all containers or no containers; some containers	When interviewee speaks about his company's experience or refers to other companies, e.g. Hapag-Lloyd	"special fleet", "full fleet", "fleet within a fleet", "reefer", "sensitive goods"	Code any mentions of the smart container deployment and fleet management
standards compliance	Compliance of the mentioned digital accessory with hardware, software and data related standards	To recognise awareness level on local and global level	"ATEX", "IECEx", "cyber security", "national legislation", "international standard"	Code all related to the discussed technology and personal beliefs and activities in standardisation efforts
personal feelings	Expressions showing beliefs and assumptions about the smart	To anchor when the interviewee expresses his opinion.	"I believe", "I think", "I am afraid", "off the record"	Code when the statements are done on assumptions, rather than on proven facts

	container development			
Background	Refers to industrial background of the interviewee	Applies when the interviewee explains his professional background, the industry he is coming from and long-term engagement with any relevant institutions	"…years in the industry/company/ maritime business" "convenor/chair of working group/sub-committee" of a standardisation body	Code when the background is explained and mentioned as an add on during answering the questions
Data ownership and usage	Data that smart container generates directly and indirectly, both on cargo condition and the container movement	When interviewee mentions any decisions related to data ownership, data sharing principles and details on its applications	"client's data", "internal use", "port authorities", "cargo owners"	Code when the concept is explained and / or examples are raised
external user of IoT	A stakeholder, for whom the smart container data is made available by the smart	When interviewee mentions parties like clients, partners or authorities that	"port authorities", "customs", "carrier", "cargo owner"	Code when the stakeholders types are stated

	container owner	receive the smart container updates		
internal users	Smart container owners	When interviewee speaks about their own company users	“COSCO”, “OOCL”, “booking department”, “fleet manager”	Code when the company internal stakeholders are mentioned
standardisation bodies	Global and regional institutions which define the standards related to the smart container	When the company involvement in the institutions or a level of smart container compliance with existing regulations and standards is mentioned	“ISO”, “SAC”, “IMO”, “IMDG”, “DCSA”	Code when the involvement or proactive lack of compliance is mentioned
subsidised or led by the government	Financial support or intellectual ownership	When governmental financial support or supervision is mentioned on smart container technology	“research & development budget”, “tax discount”, “funding”	Code when the question on governmental funds and involvement is answered or avoided

		development, production and deployment.		
technology origin	Where is IoT technology is design and produced	When the geographical locations of companies and production lines are mentioned	"made in …", "price decides", "we need to control the production process"	Code when answered directly or provided a principle to choose a technology origin
challenges in tech implementation	Any issues related to the technology deployment	When examples or theoretical assumptions are raised	"there is no demand", "we have tested this technology and decided…"	Code when financial, technological (hardware or software) challenges are raised
data locality and security	The origin of the data and its cyber protection	When data harvesting and data application approaches are mentioned	"client's ownership", "COSCO", "OOCL", "API", "platform to platform integration"	Code when concepts are clearly stated or avoided
future tech	Insights on the smart container technology development	Any visionary statements on the smart container development	"tag", "IoT", "sensors", "door open/close", "temperature control"	Code when the vision is presented, both on company and private level

4.5.3 Intercoder Reliability

Intercoder reliability (ICR) was assessed to ensure that the thematic analysis produced consistent and credible results. Krippendorff's (2018) alpha (α) was selected as the reliability coefficient because it accommodates different numbers of coders, incomplete coding, and varying forms of qualitative data, while applying a more rigorous correction for chance agreement than Cohen's kappa (Krippendorff, 2018; Hayes & Krippendorff, 2007). Krippendorff's (2018) alpha is widely recognised as the most suitable reliability statistic for qualitative research where categories may be interpretive, context dependent or linguistically complex (Lombard, et al., 2002; ATLAS.ti, 2024).

The intercoder reliability test was conducted on the original Chinese language transcripts to verify that the coding structure functioned consistently at the source language level. This step was necessary because the interviews contained terminology, institutional expressions and culturally embedded reasoning that cannot be reliably evaluated through translation alone. The assessment involved two coders: the principal researcher, Marianna Levtov, and Ms YinYing Kong, a native Chinese speaker. Both coders applied the same codebook and coded the same segments independently. This made it possible to evaluate whether the coding scheme developed earlier in the analysis was sufficiently stable, coherent and transferable across coders with different linguistic backgrounds.

For this study, the ICR exercise served two important methodological purposes. First, the ICR confirmed that the categorisation and coding framework could be reliably applied to Chinese language data without distortion arising from translation or interpretive drift. Second, the intercoder reliability provided an external verification of the principal researcher's analytical decisions, reducing the risk that coding outcomes were shaped by individual assumptions or by the challenges of operating across languages. Establishing reliability in this way strengthened the dependability, confirmability and overall trustworthiness of the analysis, in line with the qualitative rigour criteria proposed by Lincoln and Guba (1985).

The resulting reliability score demonstrated that the coding structure was sufficiently robust to support the subsequent thematic interpretation. This confirmation was essential given the central role of coding in linking the study's research questions with the empirical material. The next subchapter, therefore, turns to methodological reflection,

examining how reflexivity was maintained throughout the research process and how assumptions, positionality and interpretive decisions were managed to ensure analytical integrity.

4.5.4 Self-Reflection

Tracy (2010) identifies sincerity as an essential criterion for high quality qualitative research, grounded in transparent reporting of methods and in explicit self-reflection on the researcher's own position and assumptions. In a study such as this, where meaning is produced through interaction, interpretation and translation, these elements are not optional; they are critical for demonstrating that the analytical claims rest on a transparent and accountable process. Reflection therefore serves as a methodological tool rather than a personal exercise. Self-assessment clarifies where interpretive decisions originate, how they were evaluated and how any potential distortions were addressed, which directly strengthens the credibility of the study.

Ortlipp (2008), following Denzin (1994) and Mrunck and Breuer (2003), argues that a reflective stance makes visible the constructive nature of qualitative analysis and the subjectivities that shape it. This insight was particularly important for this research because interviews were conducted in Chinese, analysed across languages and involved participants embedded in a highly structured institutional environment. The interpretive choices required at each step made ongoing reflection indispensable. This subsection therefore outlines how reflexivity was integrated into the analytical process and how it contributed to the trustworthiness of the findings.

A structured reflective journal was maintained throughout all stages of fieldwork, including interview preparation, questioning, transcription, translation, coding and thematic interpretation. The purpose of this journal was to document assumptions, emerging interpretations, and areas of uncertainty, providing a running audit trail of interpretive decisions. In parallel, Ms YinYing Kong, a native Chinese speaker and external observer, kept her own notes during the interview and coding phases. The comparison of these independent reflections added a second interpretive viewpoint and was especially important for verifying meaning in Chinese expressions that carry cultural connotations, potentially not directly transferable into English. The inclusion of a reflective interview with Ms Kong in Appendix II reinforced the transparency and

triangulated nature of this interpretive process. Her reflections confirmed that the Chinese interviews were conducted in an ethically appropriate and culturally sensitive manner, and that the bilingual analysis preserved the meaning and intention of the participants' responses. Ms Kong emphasised that although linguistic nuance always requires caution, no substantive differences in meaning emerged between the corrected Chinese transcripts and the English translations used for coding. Although a linguistic analysis was also conducted, its analytical value for this study proved marginal and is therefore not presented within this research project. Importantly, because Ms Kong was not familiar with the logistics sector and did not know the interviewees personally, her coding offered an independent check that interpretation was not shaped by prior knowledge of the field. This convergence between her evaluations and the researcher's analytic decisions strengthened confidence that the themes developed were rooted in what participants said, rather than influenced by disciplinary assumptions or insider familiarity. Together, these reflections demonstrated that the bilingual and reflexive procedures employed were effective in safeguarding the integrity of meaning across languages and ensured that the interpretive process was both transparent and analytically defensible.

The positionality of the researcher also required explicit consideration. Following Adler and Adler's (1987) typology, this project involved both active member observation and peripheral member observation. The principal researcher held an insider position with established access to the Chinese smart container domain but did not adopt organisational values or goals. This position facilitated access to senior industry actors who might otherwise have been unreachable, aligning with Dwyer and Buckle's (2009) argument that insider status can enhance credibility and depth. In contrast, Ms Kong operated as a peripheral observer, providing external linguistic and cultural validation without engagement in domain specific norms. This dual positional structure enriched the analytical process by balancing interpretive depth with critical distance.

Reflection was particularly important in managing the tension between insider access and analytical independence. Throughout the interviews, the researcher consciously avoided aligning with participants through use of inclusive language or sector affiliation, maintaining a clear distinction between "researcher" and "industry actor." This distancing was crucial for reducing the risk of unexamined agreement or tacit acceptance of institutional narratives. The reflective journal captured moments when insider familiarity

might have influenced questioning, probing or interpretation, ensuring that these moments were recognised and corrected in subsequent analysis.

Maintaining reflexivity also contributed directly to the rigour of data analysis. During coding, the combination of reflective notes and the insights provided by the external observer helped identify when certain interpretations stemmed from prior industry knowledge rather than the data itself. This process created the necessary analytical distance required by thematic analysis and is consistent with the constructivist orientation underpinning the methodology. Reflection was therefore not a secondary activity but a mechanism for ensuring that codes, categories and themes were grounded in the participants' accounts rather than in professional assumptions.

In summary, reflexive practice strengthened this study by making interpretive decisions transparent, balancing insider and outsider perspectives, and ensuring that linguistic, cultural and institutional complexities were handled with methodological care. Reflection supported the credibility and dependability of the findings and reinforced the interpretivist constructivist principles that guided the study's design and analysis.

Table 4.4: Steps of Thematic Analysis by Authors and the Steps Chosen for This Research

Step/Phase	Creswell and Creswell (2018)	Denzin and Lincoln (2018)	Bryman (2016)	Kuckartz (2014)	Smart container Research
1. Organizing the Data	Transcription, sorting, and preparation of data for analysis.	Immersion in data, familiarizing, and organizing.	Organizing data into manageable formats, preparing for analysis.	Development of categories based on empirical data. Transcription and preparation of data for analysis, organizing for easy access.	Development of Categories based on empirical data
2. Reading Through Data	Engaging with the data to get a general sense.	Close reading and listening to understand depth and context.	Initial reading to identify patterns and themes.	Creating Guideline for Analysis. Close reading to become familiar with the data, define categories from Step 1, summarize to create a guideline.	Initial Reading to identify Patterns and Themes
3. Coding	Identifying and labelling data segments with codes.	Developing initial codes from data.	Systematic coding of data to categorize information.	Code the Data. Assess data according to analysis guideline and code-book. Code	Developing Initial Codes from Data

Step/Phase	Creswell and Creswell (2018)	Denzin and Lincoln (2018)	Bryman (2016)	Kuckartz (2014)	Smart container Research
				data by assessing it to evaluative categories.	
4. Generating Themes	Combining codes to form themes.	Thematic analysis to identify and refine major themes.	Identifying key themes through the aggregation of codes.	Set up Tables and Overviews. Present the results in table, that includes the frequences of categories appearance. Create crosstabs to present relationships between two or more categories.	Combining Codes to Form Themes
5. Developing Descriptions	Detailed description of themes, integrating literature.	Narrative development to describe and interpret findings.	Building descriptive narratives around themes.		Building Descriptive Narratives around Themes
6. Interpreting Data	Linking the analysis to research questions and theoretical framework.	Theoretical integration and contextual interpretation of data.	Contextualizing findings within theoretical frameworks.	In-depth Interpretations of Individual Cases. Interpretation of themes and cross-case analysis (if applicable).	Theoretical integration and contextual interpretation of data.

Step/Phase	Creswell and Creswell (2018)	Denzin and Lincoln (2018)	Bryman (2016)	Kuckartz (2014)	Smart container Research
7. Representation	Structuring the narrative, including data excerpts to support findings.	Representing findings through narratives, visuals, and theoretical lenses.	Presenting the analysis in structured formats with supporting evidence.	Writing and presentation, emphasizing the connection between data and emerged themes.	Writing and presentation, emphasizing the connection between data and emerged themes.
8. Validity	Ensuring credibility through various strategies like member checking.	Employing strategies for credibility and trustworthiness.	Emphasizing the importance of reliability, validity, and generalisability.	Integration of quantitative methods for enhancing robustness of findings.	Emphasizing the importance of reliability, validity, and generalizability.

4.5.5 Researcher Bias

Researcher bias in qualitative research refers to systematic distortions introduced by the researcher that may influence the collection, interpretation or representation of data. Because qualitative inquiry positions the researcher as the primary instrument of data generation and analysis, sustained awareness of potential bias is central to ensuring credibility and trustworthiness (Galdas, 2017). Unlike quantitative designs, where bias may be mitigated through standardised procedures or statistical controls, qualitative research requires methodological transparency and reflexive strategies that acknowledge and manage the researcher's subjectivity (Zahle, 2024; Braun & Clarke, 2024).

Bias may arise at multiple points during a study. During data collection, it can manifest through selective engagement with participants, subtle framing of interview questions or over-identification with certain perspectives (Padgett, 2008, as cited in Zahle, 2024). In the analytic stage, interpretive bias may occur when researchers privilege data that confirm existing assumptions, overlook contradictory material or selectively emphasise expected themes, a phenomenon commonly described as confirmation bias (Nowell et al., 2017; Berger, 2015). Galdas (2017) notes that such tendencies risk undermining the depth and balance of qualitative findings. Common forms of qualitative bias include confirmation bias, cultural bias, selection bias and interpretation bias (Goyanes et al., 2025; Muthanna & Alduais, 2023), often operating simultaneously given the inherently interpretive nature of qualitative work.

Recent literature challenges the assumption that bias is either unavoidable or unmanageable. Zahle (2024) proposes that bias can be addressed through two complementary strategies: bias prevention and bias checking. Prevention involves maintaining descriptive adequacy, balance and sufficiency while remaining attentive to the influence of personal commitments or expectations. Checking requires researchers to seek both confirming and disconfirming evidence throughout the process and adjust their procedures accordingly. These strategies operationalise reflexivity and strengthen the internal validity of qualitative inquiry.

Similarly, Muthanna and Alduais (2023) emphasise reflexivity as a core competence for identifying how researcher positionality, worldview and professional experience shape

data interpretation. Reflexivity entails deliberate self-examination of assumptions, decisions and interpretive tendencies (Malterud, 2001; Holmes, 2020). Maintaining a reflexive journal and engaging in peer debriefing are well-established methods supporting this practice (Bryman, 2012; Lincoln & Guba, 1985). In this study, such reflexive practices supported transparency in decision making, interpretation of bilingual material and repeated evaluation of the researcher's own influence on the coding process.

Given the researcher's professional background, the potential for interpretive bias required attentive mitigation. The principal researcher, Researcher Levtov, has worked in the smart container and intermodal transport sector since 2018 and holds roles within international standardisation bodies such as UN ECE/CEFACT and ISO TC 104. This degree of industry embeddedness provided valuable contextual understanding but also introduced the possibility of familiarity bias. To counter this, reflexive journaling, systematic documentation of analytic decisions, triangulation with academic sources and iterative peer review were applied. Coding reliability was further supported through an intercoder reliability exercise with native Chinese speaker Ms YinYing Kong, who independently coded selected transcripts in Chinese. This cross-verification acted as a checking mechanism, strengthening neutrality and reducing the risk that prior industry knowledge would shape analytic outcomes.

Although complete objectivity cannot be achieved in qualitative research, sustained reflexivity and structured debiasing strategies significantly reduce the likelihood of distortion (Zahle, 2024; Braun & Clarke, 2024; Muthanna & Alduais, 2023). Through methodological transparency, active reflection and external verification, this study sought to ensure descriptive adequacy, analytic balance and interpretive coherence, in line with Lincoln and Guba's (1985) framework for qualitative rigour.

In conclusion, this study approached researcher bias as a methodological dimension requiring explicit management rather than a flaw to be removed. Reflection, triangulation and bilingual peer coding supported disciplined interpretation and safeguarded analytical neutrality, enabling the findings to retain contextual richness while preserving methodological integrity. These practices enhanced the dependability and credibility of the research and strengthened the transferability of its conclusions within the wider discourse on digitalisation, data governance and regulatory evolution in global logistics.

4.5.6 Recording and Transcription

All interviews in this study were audio recorded and subsequently transcribed verbatim. The interviews were conducted via Zoom and recorded directly through the platform. Most interviews were held in Chinese, and in cases where participants preferred or required English, the interviews proceeded in English. The use of recording ensured accurate and comprehensive data capture, providing a reliable foundation for subsequent analysis (Bryman, 2016; Nowell et al., 2017). Audio files served as a permanent record of the interaction and enabled the researcher to revisit nuances of tone, emphasis and hesitation that informed the interpretation of meaning. The recordings also preserved elements of communicative context, including pauses, laughter and shifts in intonation, which might otherwise have been lost through notetaking alone (Kvale & Brinkmann, 2015).

Beyond functioning as a correction tool for the limits of memory, the recordings enabled reflexive engagement with the interviewing process, allowing the researcher to evaluate question phrasing, sequencing and the degree of prompting used (Seale, 2018). Listening to recordings offered opportunities for critical self-assessment and methodological refinement, ensuring that the researcher's tone or positionality did not inadvertently influence how participants responded.

The transcription process converted spoken data into written form suitable for systematic coding and thematic analysis. The Zoom platform's automated transcription function provided an initial version, but each transcript was checked manually to ensure accuracy. For the Chinese language interviews, the transcripts were reviewed together with Ms YinYing Kong to correct errors resulting from automated transcription, particularly those caused by dialectal variation and technical terminology. Following verification, the Chinese transcripts were translated into English in a controlled manner to preserve accuracy and conceptual integrity. Transcribing verbatim preserved linguistic detail and authenticity, supporting interpretive validity (Oliver et al., 2005). Each transcript was reviewed multiple times against the original recording to ensure completeness. Non-verbal cues relevant to meaning, such as long pauses or marked shifts in tone, were annotated where analytically appropriate, strengthening dependability and confirmability (Lincoln & Guba, 1985).

To maintain data integrity, all audio recordings were stored securely in encrypted digital format, and transcription files were password-protected. Access to these materials was restricted to the researcher and authorised collaborators, in accordance with ethical and confidentiality requirements (Saunders et al., 2015). Participants were informed in advance that their interviews would be recorded and transcribed, and their consent was obtained prior to commencement.

Finally, the transcripts served not only as the foundation for coding but also as a tool for transparency and peer review. Making transcripts available for verification enables other researchers to re-examine the data or evaluate alternative interpretations (Bryman, 2016). This approach aligns with best practice in qualitative research, where transparent documentation strengthens both credibility and the replicability of the analytical process (Braun & Clarke, 2024).

In conclusion, the combined process of recording, transcription and collaborative verification provided a robust and transparent foundation for the subsequent stages of analysis. By integrating automated and manual transcription, bilingual verification and secure data management, the study ensured both accuracy and contextual fidelity in its qualitative material. These procedures enhanced the trustworthiness of the empirical base and supported the analytical depth required for interpreting complex cross-cultural insights in the Chapters Five and Six.

4.5.7 Analysing the Data

The analysis of the interview material followed an interpretivist logic, recognising that meaning is constructed through the interaction between the researcher, the participants and the broader institutional environment, which in this study includes state-led industrial programmes such as *Made in China 2025* and the Belt and Road Initiative, together with the People's Republic of China's regulatory framework for data and cybersecurity. Regulations such as the Data Security Law (DSL), the Personal Information Protection Law (PIPL) and the enforcement mechanisms of the Cyberspace Administration of China (CAC) shape how actors articulate digitalisation, technological sovereignty and the governance of cross-border data flows within the context of container technologies.

This subsection reflects backward engineering principles, presenting the analytic pathway in the sequence in which it occurred. The process relied on both deductive framing and inductive discovery, and, therefore, drew on established qualitative guidance from Creswell and Creswell (2018), Denzin and Lincoln (2018), Bryman (2016) and Kuckartz (2014). These frameworks were adapted to the specific cultural and political conditions of the Chinese smart container context, where terminology, organisational discourse and state priorities are tightly interwoven.

The first stage involved preparing and organising the empirical material. The Chinese transcripts generated by Zoom contained distortions in technical vocabulary, professional expressions and institutional references. These inaccuracies required careful manual correction before coding could begin. English translations were then produced to allow bilingual analysis. This preparatory phase reflects Creswell and Creswell's (2018) recommendation that data be cleaned and systematically organised prior to analysis, Denzin and Lincoln's (2018) view that immersion in the raw material is necessary for interpretive depth, and Bryman's (2016) emphasis on structuring transcripts in ways that enable repeated analytic engagement. Kuckartz's (2014) guidance on establishing a clear organisational structure for theme-oriented analysis further informed this stage. In this study, the data were coded in both Chinese and English to preserve the precision of meaning, particularly for expressions linked to state responsibility, technological ambition and national digitalisation policy, whose nuances are anchored in the Chinese political and institutional context.

Following data preparation, the transcripts were read repeatedly to build familiarity with the content and identify preliminary patterns. Creswell and Creswell's (2018) emphasis on gaining an overall understanding of the data, Denzin and Lincoln's (2018) insistence on close reading as a means of accessing latent meaning, and Bryman's (2016) view that early readings help surface emerging themes all shaped this stage. Kuckartz's (2014) approach, which stresses the importance of repeated reading to support the development of analytic categories, was similarly applied. For this study, close reading served a crucial function: it enabled the researcher to differentiate between participants' personal interpretations and the institutional narratives that frequently shape accounts in state-influenced sectors. In the Chinese logistics and digitalisation environment, where

organisational discourse is tightly coupled to national strategy, this distinction was analytically important.

Coding formed the core phase of the analysis. The initial coding framework was deductive, derived from the research questions and the literature on smart containers, technology origin, data governance and standardisation. This reflects Miles, Huberman, and Saldaña (2019) structural coding approach, which ensures alignment between research questions and early analytic categories, and Linneberg and Korsgaard's (2019) warning that purely inductive coding can dilute analytical focus. However, inductive coding soon became necessary as participants introduced new conceptual distinctions, priorities and linguistic patterns that were not represented in the literature. Denzin and Lincoln's (2018) principle that initial codes should reflect the empirical data supported this inductive expansion, while Guest et al.'s (2012) definitions of code, codebook and segment structured the technical process of coding. Because the interviews were conducted in Chinese, coding was performed first on the original Chinese transcripts and subsequently on the English versions. This ensured that analytic decisions reflected the cultural nuances embedded in participants' accounts.

Reflective notes played a central role throughout the analytic process. Following Charmaz's (2006) guidance, the notes were written continually to document interpretive decisions, uncertainties, conceptual developments and ideas for category refinement. Clark et al.'s (2021) argument that notes writing produces transparency and creates an audit trail further justified its use. Given the bilingual nature of the study, notes writing was not limited to the principal researcher: Ms YinYing Kong, a native Chinese speaker and external observer, kept separate reflective notes during the coding and review process. The comparison of these reflections helped identify potential misinterpretations arising from translation, institutional framing or cultural inference. This dual-reflection system added interpretive stability and strengthened the credibility of coding decisions.

As coding progressed, categories were refined through the iterative process described by Braun and Clarke (2024) and by Kuckartz (2014). Some categories required subdivision when participants' accounts revealed distinctions not captured in the initial deductive framework, for example, differentiating between challenges for the smart container adoption to the price related factors and technology readiness level. Other codes were

collapsed after repeated analysis demonstrated that they represented minor variations of the same core meaning. This iterative refinement ensured that the analytic structure remained empirically grounded, theoretically coherent and sensitive to the institutional and cultural specificities of the Chinese context.

Themes were then developed by aggregating related codes and identifying recurring patterns across interviews. Creswell and Creswell's (2018) guidance on forming themes through the combination of codes provided the basic structure, supplemented by Bryman's (2016) emphasis on identifying overarching concepts and Denzin and Lincoln's (2018) view that themes must reflect the contextual environment in which meaning is produced. For this study, themes such as technological readiness, standardisation role, and the data governance emerged only when the coded patterns were considered in relation to China's broader developmental-state context. These themes were confirmed through the interpretive abstractions grounded in the empirical data.

The interpretive phase connected these themes to the theoretical framework and research questions. Creswell and Creswell (2018), as well as Bryman (2016) highlight the need to integrate findings with theoretical constructs, while Denzin and Lincoln (2018) emphasise the contextualisation of interpretation within broader sociocultural systems. This was particularly important in this study because the participants' accounts were influenced by national industrial strategy, geopolitical expectations and the economy of smart container technology. Interpretation, therefore, required attention not only to what participants said but also to how they framed their positions, justified their reasoning and positioned China relative to global developments.

The final analytic stage involved presenting the findings in a structured, transparent and coherent manner. Creswell and Creswell's (2018) recommendations on presenting themes supported by quotations and Bryman's (2016) emphasis on clear reporting guided the representation. Kuckartz's (2014) requirement to connect interpretive claims explicitly to coded segments ensured that the presentation remained empirically traceable. The use of bilingual excerpts further enhanced transparency by enabling readers to understand key concepts within their cultural context.

Validity concerns were addressed throughout the process. Triangulation across interview data, academic literature, policy documents and industry sources added depth and

contextual grounding. Intercoder reliability and reflexive journaling enhanced credibility and dependability, consistent with Lincoln and Guba's (1985) criteria for qualitative rigour. These measures were particularly important given the political sensitivity of the topic, the dual-language nature of the data and the potential for institutional influence on participants' accounts.

In summary, the analysis followed a transparent, rigorous and theoretically grounded pathway. The approach integrated deductive structure, inductive flexibility, bilingual precision and reflexive awareness, ensuring that the findings reported later in the study are both empirically supported and methodologically robust.

The data analysis process described in this Chapter brought together the interpretive procedures necessary to examine how Chinese industry actors understand and enact container digitalisation and data governance. By integrating structured coding, iterative theme development, bilingual verification, reflexive practice and systematic reliability checks, the analytical approach ensured that the findings rest on a transparent and defensible evidential base. Each component of the analysis contributed to the credibility and interpretive depth of the study. Recording and transcription secured an accurate empirical foundation. Coding and theme construction provided the analytical architecture for identifying patterns across interviews. Intercoder reliability established consistency in the handling of bilingual material, and reflexive engagement mitigated the influence of researcher positionality. Collectively, these elements produced an analysis that was theoretically coherent, empirically grounded and sensitive to the institutional and political context in which participants operate. This methodological rigour forms the basis for the presentation and interpretation of findings in the next chapter.

4.6 Ethical Considerations

Ethical practice is fundamental to qualitative research, particularly when studies involve organisational actors who may hold sensitive responsibilities or operate within politically structured environments. Neuman (1997) identifies privacy, anonymity and confidentiality as three core components of ethical responsibility that apply to all researchers. Walker (1980) similarly argues that ethical considerations should prioritise the confidentiality of collected data, the protection of individuals' control over personal

information, and the maintenance of anonymity for all interviewees. Trochim (2006) adds that informed consent, voluntary participation, protection from harm and the safeguarding of confidentiality and anonymity form the basis of contemporary ethical protections in social and medical research. Easterby-Smith and colleagues (2012) emphasise that ethical procedures must protect both individuals and organisations, particularly when the research concerns areas of strategic, commercial or political sensitivity. These principles were directly relevant to this study, since the topic of digitalisation and data governance in China involves information that may influence organisational relations, regulatory compliance and international perceptions.

The study adhered to the ethical guidelines of the University of Gloucestershire, which require that participation be voluntary and that individuals retain the right to withdraw at any stage without consequence (University of Gloucestershire, 2023). This right was communicated clearly before each interview, together with an outline of the research purpose, the themes to be discussed and a formal consent letter (Appendix 1). Participants were invited to select an interview time and video conferencing tool of their preference and were offered the option to conduct the interview in Chinese. This flexibility ensured that participants were able to express themselves in a manner that was comfortable, culturally appropriate and linguistically precise.

All interview data were transcribed and returned to participants for review. They were given the opportunity to correct, redact or withdraw their contributions within one month of receiving the transcripts. This procedure supported participants' control over their data and is consistent with Neuman's (1997) requirement for privacy and Walker's (1980) emphasis on individual autonomy in relation to research material. The data generated are stored securely, in accordance with university policy, and used solely for the purposes of this study.

Anonymity was safeguarded by removing identifiable personal information from the analysis and by presenting participants' roles in general terms Bryman and Bell (2011) note that anonymisation is essential when interviewees' positions could expose them to organisational scrutiny or when topics involve institutional sensitivity. Although several participants indicated that they were comfortable being identified, no personal or organisational details were disclosed in the research, ensuring a uniform level of

protection for all contributors. This consideration was particularly important in the context of Chinese digitalisation policy, where organisational hierarchies and state expectations may shape what interviewees feel able to disclose. By removing any identifiable information, the study increased the likelihood of obtaining candid and detailed accounts, which strengthened both ethical integrity and analytical validity. Overall, ethical safeguards were integrated into every stage of the research process, ensuring that participants were protected, that organisational interests were respected and that the study met the professional standards required for rigorous qualitative inquiry.

4.7 Summary and Conclusion of the Research Methodology

The methodological architecture developed across Sections 4.1 to 4.6 is built upon the theoretical and procedural frameworks of qualitative research. This study adopts a constructivist ontology and an interpretivist epistemology, operationalised through a qualitative design based on semi structured interviews, thematic analysis and grounded theory-informed coding. The constructivist orientation articulated in Sections 4.2.1 and 4.2.3 directly reflects the foundational assumptions outlined by Saunders et al. (2016), Easterby-Smith et al. (2012) and Creswell and Creswell (2018), emphasising that social phenomena must be understood as contextually constituted rather than objectively fixed. This study relies on that premise, since the meaning of the smart container in China is produced through institutional discourse, regulatory framing and political context. Denzin and Lincoln's (2018) interpretive paradigm, introduced in Section 4.1, reinforces this epistemological stance by situating knowledge production within the relationship between researcher, participant and environment.

These philosophical commitments guided the qualitative strategy presented in Sections 4.3.1 to 4.3.4. Bryman (2012), Wahyuni (2012) and Yin (2024) provide the justification for semi-structured interviews as the principal method of data collection in situations where institutional reasoning, policy interpretation and organisational meaning are not observable through documentation. Brinkmann's definition of the interview as an interactional event aligns with the bilingual and politically sensitive setting of this research, recognising that meaning is co-constructed and cannot be extracted through superficial questioning. The sampling approach described in Section 4.4.2 adheres to

Glaser and Strauss's (1967) and Charmaz's (2006) concept of saturation, later refined by Nelson, ensuring that analytical categories achieve conceptual density and are not the product of superficial repetition.

The analytical framework detailed in Section 4.5 is shaped by the grounded theory tradition established by Glaser and Strauss (1967) and reformulated by Charmaz (2014) as a constructivist methodology. Mayring's (2000) structured content analysis and Kuckartz's (2014) thematic development procedures provided the rules for coding, category refinement and theme construction. Miles and Huberman (1994) and Miles, Huberman and Saldaña's (2019) structural coding logic ensured alignment between research questions and the initial deductive frame, preventing analytical drift in an environment where insider knowledge could easily dominate interpretation. Guest et al.'s (2012) definitions of codes, codebooks and segments formed the technical basis of the coding architecture, ensuring transparency, replicability and cross-case consistency.

Braun and Clarke's (2019) thematic analysis, particularly their distinction between procedural and reflexive approaches, shaped the theme development process in Section 4.5.2. Their insistence that themes do not simply "emerge" but are actively produced by the researcher imposed necessary discipline on interpretive claims, especially given the influence of Chinese political discourse on participants' language. The bilingual coding and intercoder reliability procedures in Section 4.5.3 rely on the work of Krippendorff (2018), Hayes and Krippendorff (2007), and Lombard et al. (2002), whose reliability frameworks enabled rigorous assessment of coding stability across languages and coders. This was essential in a context where institutional vocabulary carries implicit political meanings that risk distortion in translation.

Reflexivity, addressed in Section 4.5.4, draws explicitly on Tracy's (2010) criteria for qualitative sincerity, Ortlipp's (2008) call for transparency in interpretive work and Finlay's reflexive strategies for managing researcher influence. These authors' insights were not theoretical embellishments but operational necessities given the researcher's longstanding involvement in container digitalisation and international standardisation. Denzin's (1994) interpretive sociology and Mrunck and Breuer's (2003) articulation of reflexive practice further shaped the mechanisms for identifying and mitigating interpretive bias. Section 4.5.5 incorporates Zahle's (2024) prevention and checking

model, together with reflexive frameworks from Muthanna and Alduais (2023), Holmes (2020), Malterud (2001) and Braun and Clarke (2024), to systematise the management of bias throughout data interpretation.

Recording and transcription procedures in Section 4.5.6 rely on seminal work by Kvale and Brinkmann (2015), Oliver et al. (2005) and Seale (2018), ensuring accuracy, contextual fidelity and traceability. The bilingual verification follows Bryman's (2016) and Nowell et al.'s (2017) recommendations for strengthening dependability in complex interpretive settings. Section 4.6's ethical considerations are grounded in Neuman's (1997) principles of privacy, anonymity and confidentiality, Walker's (1980) emphasis on individual autonomy and Trochim's (2006) framework of informed consent and participant protection, all of which were essential given the political, commercial and institutional sensitivities surrounding digitalisation and data governance in China.

Together, this methodological framework demonstrates that the study is not an assemblage of disconnected techniques, but an intentionally structured system grounded in established qualitative research. Saunders (2015), Denzin and Lincoln (2018), Creswell and Creswell (2018), Charmaz (2006), Mayring (2002), Kuckartz (2014), Braun and Clarke (2024), Miles and Huberman (1994), Guest et al. (2012), Krippendorff (2018), Finlay (2002), Tracy (2010) and Zahle (2024) have collectively shaped the philosophical, procedural and analytic logic of the research. Their contributions ensured that each methodological decision remained theoretically justified, operationally transparent and analytically robust.

This Chapter clarifies the boundaries of what the study can legitimately claim. This section shows that the findings presented in Chapter Five rest on a rigorous evidential base that accounts for linguistic complexity, institutional opacity and political sensitivity. The Chapter also demonstrates that the analysis is not driven by the researcher's insider familiarity but is grounded in a disciplined interpretive process supported by intercoder reliability, reflexive documentation and systematic coding procedures. The methodological architecture therefore provides a stable, defensible and credible foundation for the empirical and theoretical contributions that follow.

5 Findings of the Chinese Smart Containers Development

5.1 Introduction to the Data Analysis Results

This Chapter presents the empirical findings derived from the semi-structured interviews and analysed through the data analysis procedures outlined in Chapter Four. Its purpose is to examine how Chinese industry and policy actors interpret and operationalise container digitalisation, and to show how these interpretations answer the three research questions introduced in Chapter Two, Subsection 2.5 and developed through the literature review. The findings demonstrate how track-and-trace technology is understood within the broader context of China's digital transformation agenda, and how actors navigate the interplay between technological adoption, institutional expectations and regulatory frameworks. Interestingly, digitalisation of containers and track-and-trace technologies for containers are synonymous in the findings of this research, since track-and-trace is the major use case for smart containers. (UN ECE/UN/CEFACT, 2019).

The final stage of the research process involves interpreting the empirical patterns and drawing conclusions that meaningfully address the research questions, a process emphasised in case study design by Yin (2014). Structuring the findings around the research questions supports analytical clarity and coherence, particularly when the coding framework is built on structural codes. Guest et al. (2012) argue that aligning empirical results with research topics or research questions enables the reader to follow the analytical pathway and understand how the themes respond to the aims of the study. This rationale underpins the organisation of the present Chapter.

Sections 5.2 to 5.4, therefore, present the empirical findings in direct relation to the three research questions, showing how Chinese actors interpret track-and-trace technology, how they conceptualise data governance within digitised supply chains and how they assess the potential influence of Chinese smart containers. Section 5.5 synthesises these

thematic results to identify cross cutting patterns and institutional logics that extend beyond individual accounts.

Finally, Chapter Six mirrors this thematic structure to develop a coherent discussion that links the findings to the theoretical framework. The alignment between the structure of Chapters Five and Six ensures that interpretation proceeds systematically, enabling the study to articulate its contribution to knowledge in a clear and cumulative manner.

5.2 Smart Container Market Penetration and its Influence on the Supply Chain

This section addresses *Research Question One*: *what is the Chinese approach towards using track-and-trace technology for shipping containers?*, which will contribute to closing the first gap to identified in the literature review Chapter Two Section 2.4, which highlighted the lack of detailed academic research on smart container adoption and the absence of systematic analysis of how IoT-enabled container digitalisation influences supply chain operations.

The findings confirmed that the penetration of smart containers in China remains in a stage of gradual but uneven development. The full references to the interviews can be found in Chapter Appendices, Subchapter Appendix II Interview Transcripts and Appendix III, Table 5.1. Raza et al. (2023) identify digitalisation as a critical enabler of supply chain resilience and visibility, and the interviews substantiated this view by illustrating the growing strategic relevance of track-and-trace technology in China. Several interviewees including Interviewee 1, who described digitalisation not only as a technological improvement but as a central element of corporate strategy.

> *"Regarding (container) digitalisation, it is currently a strategic focus for our company. Ever since the previous leadership took office, there has been a full-scale push to promote digitalisation"* (Interviewee 1, Line 36-38).

Interviewee 8 further emphasised this point by underlining that the scope of digitalisation extended beyond products into broader corporate transformation:

> *"We are working very hard on the digitalisation, or I would call it digital transformation of the company, rather than the product, the product can remain traditional classic"* (Interviewee 8, Line 400-401).

These perspectives of Interviewees 1 and 8 align with Herold et al. (2021), who conceptualise digitalisation as a socially embedded process shaped not only by technological capability but also by institutional and strategic motivations.

A recurrent theme during the interviews was the perceived affordability and growing necessity of IoT-based tracking solutions, as indicated by Interviewee 6:

> *"I think today's IoT device [is] much affordable, and I think the shipping lines have actually realised that today the container has grown to the certain size and it's difficult to manage without tracking them"* (Interviewee 6, Line 51-52).

This perception of Interviewee 6 supported the argument that smart containers were moving from being experimental innovations to becoming operational necessities. Existing literature including by (Ivanov, 2021) also reflects this trajectory, with IoT devices described as central to the creation of digital twins of logistics networks and as key to improving real-time visibility and cargo safety (UN ECE, 2019). Interviewee 3 reinforced this sense of transition, remarking that IoT enhances the quality of the supply chain:

> *"I think generally, globally, such kind of IoT technology helped a lot on improving the transportation quality, you know from end to end together with the transparent transparency"* (Interviewee 3, Line 56-59).

While Interviewee 2 confirmed the trend and added:

> "*…this decision is for every shipping company, such as MSC or Hapag-Lloyd or COSCO, everyone is doing this. But now, for example, like China COSCO, mainly focusing on cold boxes*" (Interviewee 2, Line 67-68).

These observations of Interviewee 3 and Interviewee 2 suggested that Chinese companies were moving beyond pilot projects towards operational roll-out, supporting Cortes-

Murcia et al.'s (2022) conclusion that digital tools were beginning to transform logistics ecosystems in practice. Despite this momentum, several respondents stressed that adoption remained fragmented. Interviewee 8 noted significant reluctance among leasing companies:

> *"If you want them to install for everyone, never mind if they need or not. For even for a small money, they will refuse it. […] Leasing companies: 50% of the ownership has no interest, no fundamental interests in the smart container"* (Interviewee 8, 227-228; Line 101-102).

Despite the recognition of the spreading digitalisation tend, the Interviewee 2 importantly emphasised his concerns related to the level of maturity of the IoT technology for the full fleet and in particular for the dry containers:

> *"I do not know if it is dry containers, the technology is not mature ah, etc., this time to see, (but) this is certainly a trend"* (Interviewee 2, Line 69-71).

The viewpoint of Interviewee 8 and Interviewee 2 indicated that while shipping lines and operators were more active in promoting adoption, lessors displayed limited motivation, even when costs were low also there might be some technological development, which needed for the digitalisation process to spread faster. This structural divide echoed Raza et al.'s (2023) observation of a digital divide in maritime transport. Furthermore, the reluctance of lessors confirmed the limitations of the existing literature, which often lacks detailed analysis of uneven adoption patterns across ownership categories. Overall, the interviewees also referred to more forward-looking applications of digitalisation. Interviewee 1 outlined ambitions to develop artificial intelligence-enabled inspection:

> *"We aim to include AI-based container inspections and standards related to digitalisation, creating a foundation for more forward-looking developments. We plan to finalise these standards"* (Interviewee 1, Line 201-203).

This was similarly shared by Interviewee 5 who emphasised system-wide transparency:

> *"These technologies will enhance real-time tracking, improve security, and enable more efficient resource allocation. The goal is to create a fully*

> *interconnected and transparent supply chain that benefits all stakeholders"* (Interviewee 5, Line 150-152).

These aspirations corresponded to the academic literature, which anticipates that digitalisation will not only improve efficiency but also reduce risks and enable predictive analytics (Kuo et al., 2022). However, several of the participants including Interviewee 3 highlighted persistent challenges, particularly interoperability and regulatory fragmentation.

> *"I think standardisation is still a problem here at the industry. Components inside of the device while the communication is a very complicated topic in the world and the container body is a kind of a standard. It's a kind of a product that [is] following the ISO standards; we always see that the container is manufacturing with a strict standard as well as the transportation is being regulated by the international standards. Thus, if we install a smart device onto the container sometimes it will cause some compliance problems in some countries. That's how to see an issue and unknown problem"* (Interviewee 3, Line 104-116).

This concern expressed by Interviewee 3 underscored the friction between innovation and regulation in highly standardised environments, an issue that has also been highlighted in the literature (Bumann & Peter, 2019; Lind et al., 2021). Finally, the importance of fair competition and inclusive participation in standardisation processes was underlined by Interviewees 5 and 6. For Interviewee 5 it was the need for standardisation and need for collaboration amongst international stakeholders:

> *"There is a need for standardised protocols and regulations to ensure compatibility and security across different systems. Collaboration among international stakeholders is crucial to address these challenges and drive the industry forward"* (Interviewee 5, Line 157-159).

This was the same for Interviewee 6 who warned against monopolisation:

> *"So I know that there are certain requirements that they need to make sure that it will not be being 'moralised' by any of the entity who uses the device or, and that means that all the IoT device providers are able to participate at*

the same time and also adopt the certain standards" (Interviewee 6, Line 324-326).

The perspective of Interviewees 5 and 6, emphasised and support the inclusivity advocated by Herold et al.'s (2021) who contended that digitalisation is shaped by collective narratives and ecosystem alignment.

In summary, the findings above related to smart container market penetration and its influence on the supply chain demonstrate that the Chinese approach towards using track-and-trace technology for shipping containers is characterised by both strategic endorsement and fragmented implementation. Operators and large shipping companies actively pursue adoption, but lessors remain hesitant. Although IoT solutions are increasingly affordable and strategically recognised as necessary, the interviewees underscore the unresolved regulatory issues, lack of and interoperability as the constrains for broader smart container distribution. These results confirm the relevance of the first gap by providing empirical evidence on how Chinese companies adopt and frame container digitalisation, an area that has been underexplored in academic research. They offer a nuanced perspective on *Research Question One*, showing that the Chinese approach is uneven deployment of smart containers, shaped by strategic narratives at the organisational level but constrained by commercial and institutional realities.

5.3 Data Governance and Sovereignty

This section addresses *Research Question Two*: *what is the Chinese perspective on data ownership and sharing in the digitised supply chain?* Which will contribute to closing the second gap identified in literature review Chapter Two Section 2.4.1.2, which noted unresolved concerns about cybersecurity, data ownership, and the lack of empirical evidence on how sovereignty and mistrust restrict cross-border data flows.

The empirical findings revealed a layered and context dependent Chinese perspective on data ownership and sharing, reflecting a cautious yet evolving approach shaped by strategic, commercial, and regulatory considerations. At the core of this perspective is the principle that data ownership rests with the party that commissions or funds the data collection, usually the shipping line, the shipper, logistics provider, or container owner. This contractual logic was articulated clearly by Interviewee 3, who stated:

> "*Data belongs to the end user, and [Name of the Chinese IoT provider] never controls or occupies the data*" (Interviewee 3, Line 240-242).

Interviewee 6 agreed with Interviewee 3 and explained that the shipper is seeking to track their goods irrespective of the company:

> "…*if the shipper requests that they want to track their goods from point to point, then they will share with that particular shipper*" (Interviewee 6, Line 293-294).

These perspectives align with the contractual ownership models highlighted in the literature (Offor, 2020; Reid, 2025), and with the broader theoretical framework, which emphasises that in China, contractual practices are embedded within a statist sovereignty regime defined by instruments such as the Data Security Law (DSL) and the Personal Information Protection Law (PIPL) (Zhang, 2024).

Beyond confirming contractual ownership, the findings highlighted widespread concerns over trade secrets and confidentiality, which can be a significant barrier to open data exchange. Interviewee 1 emphasised:

> "*I feel there is a concern about trade secrets in this area*" (Interviewee 1, Line 152-156).

while Interviewee 8 described how lessors deny operators access to data, noting:

> "*And they [Container operators] don't want us [lessors] to know their business*" (Interviewee 8, Line 75).

These insights of Interviewee 8, along with Interviewees 3 and 6 demonstrate that actors could use data restrictions as competitive strategies, consistent with the literature's concerns about the risks of data leakage and manipulation (Neutze & Nicholas, 2013-2014). The perspectives also reflect Aaronson's (2021) argument about authoritarian digital mercantilism, where data is framed as a strategic resource to be amassed and controlled rather than openly shared.

However, the findings also indicated areas of potential openness under strictly defined conditions. As Interviewee 7, for instance, suggested:

> "*They can share the data with other companies… if you can share, it may be more conducive to development*" (Interviewee 7, Line 302-303).

This conditional willingness to share data corresponds to the literature emphasizing the trade facilitation potential of cross-border flows (UN ECE, 2019). However, rather than representing a systematic practice, this openness is contingent upon contractual requests or international agreements, reflecting what Couture and Toupin (2019) and Vatanparast (2020) who highlighted the elasticity of sovereignty, the stretching of state control into transboundary data while allowing exceptions under controlled frameworks.

A notable contradiction emerged between policy rhetoric and operational reality. Interviewee 5 highlighted the role of IoT, AI, and cloud-based data analytics in advancing national goals of digitalisation and international standardization:

> "*The goal is to integrate advanced digital and AI technologies into these standards, fostering industry growth. International collaboration in standardisation is essential, as container logistics is inherently global. China aims to contribute to these standards, promoting global compatibility and efficiency…China participates in national, industry, and enterprise standards, with ISO being the most prominent. National standards are overseen by the National Standards Committee (SAC), and container standards are managed by the Ministry of Transport's Standardization Committee. China actively engages in ISO standards to promote advanced digital and AI technologies, fostering industry development*" (Interviewee 5, Line 81-84; Line 112-116).

Interviewee 5 continued to explain his view on the further integration of the digitalisation tools into the logistics:

> "*The future of smart ports and digital logistics is promising. With the continuous advancement of technology, we can expect further integration of IoT, AI, and blockchain into logistics processes*" (Interviewee 5, Line 148-150).

This outcome of Interviewee 5 aligns with the Chinese government's framing of initiatives such as the Digital Silk Road, which promotes openness and standardisation as

part of China's global digital strategy (Al Shaher et al., 2023). Yet operational practices were more restrictive, as Interviewee 2 emphasised:

> "*We are not doing the sharing and processing of this digital ourselves… and I think it will be the same in the future*" (Interviewee 2, Line 146).

This perspective of Interviewee 2 contradiction reflects the broader tension identified in the theoretical framework that while China's legal instruments (DSL, PIPL) present data as a sovereign asset to be protected, public discourse projects an image of openness to international collaboration. LOGINK, China's centralised logistics data platform, exemplifies this contradiction by being promoted as a tool for efficiency and interoperability while simultaneously embedding mechanisms of state oversight and sovereignty into its infrastructure (USCC, 2022; Hummel et al., 2021).

The outcome of the interviews therefore suggest that the Chinese perspective is best described as cautious, sovereignty-oriented, and commercially protective, but with selective openness under tightly governed circumstances. Contractual ownership, trade secret protection, and legal compliance shape the dominant practice, while conditional international collaboration represents only a limited extension. This mixed stance reinforces the theoretical claim that data infrastructures are not neutral but are sites where political and institutional rationalities are inscribed (Mueller, 2020; Zuboff, 2019). This perspective confirms Hummel et al.'s (2021) observation that tensions between access and control are central to data governance regimes.

In summary, the Chinese approach to data ownership and sharing in the digitised supply chain is characterised by contractual allocation of rights nested within a statist sovereignty framework. The findings demonstrate that while national rhetoric projects openness and standardisation, operational practices prioritise control, secrecy, and selective sharing. This closes Gap Two by providing empirical evidence of how cybersecurity concerns and sovereignty logics restrict cross-border flows in practice, highlighting a fundamental tension between global calls for interoperability and China's statist-commercial hybrid model of data governance.

5.4 Governmental Stimulation of the Chinese Smart Container

This section presents the findings related to *Research Question One*, *what is the Chinese approach towards using track-and-trace technology for shipping containers?* and *Research Question Three what is the potential influence of Chinese smart containers?*, which will contribute to closing two gaps identified in the literature review Chapter Two, Section 2.4, which highlighted the concerns of the absence of clarity on the extent to which Chinese governance and industrial practice align with international digitalisation frameworks and standards and the absence of empirical confirmation regarding the role of government stimulation, tax reductions, or strategic funding in supporting the adoption of container IoT track-and-trace solutions.

The findings indicate that while Chinese stakeholders consistently frame digitalisation as a strategic ambition of their companies, what is aligned with national visions such as *Made in China 2025* and the Belt and Road Initiative, implementation at the container level is fragmented, cautious, and largely market driven. Although, the interviewees present that technological capability and active involvement in international standardisation bodies are evident, however the lack of substantial subsidies and unresolved technical challenges hinder large scale deployment. This tension between declarative ambition and operational pragmatism perceived through the interviewees' response, reflects a hybrid model of digitalisation in which state rhetoric and international engagement coexist with weak domestic stimulation and uneven adoption.

5.4.1 Approach to Digitalisation: Strategic Vision versus Market Caution

The empirical findings revealed a dual narrative in China's approach to container digitalisation, shaped by the interplay between strategic ambition at the national level and market-driven caution at the operational level. Interviewee 5 outlined what they described as a tiered strategy: while national policy promotes advanced digitalisation across the transport sector, actual investment prioritises ports and infrastructures, such as terminals and smart logistics hubs, where technologies like AI, IoT, and cloud computing generate measurable efficiency gains:

> "*Shanghai Port exemplifies this with three main levels of design: using internet technology for monitoring and tracking, ensuring safety and transparency through sensors and GPS. Another level involves cloud computing for efficient data storage and sharing, enabling effective data analysis, modelling, prediction, and early warning, enhancing port efficiency. AI is also being used to further develop these technologies*" (Interviewee 5, Line 44-48).

In contrast, container-level digitalisation was depicted as secondary and often deferred due to high costs. This contrast demonstrates the gap between the ideological drive embedded in initiatives such as *Made in China 2025* and the Belt and Road Initiative (Manners-Bell, 2023), and the pragmatic constraints observed in practice.

This cautious pragmatism was further emphasised by Interviewee 3, who remarked:

> "*We are at the starting point… we provide just much dry service to specific customers as per the customer demand*" (Interviewee 3, Line 85-88).

At the same time Interviewee 3 emphasized the important factor clients demand for technology and related services, which influences the Chinese decision on how fast the smart containers to be deployed, stating:

> "*Well, for dry containers, we are at the starting point. We provide just much dry service to specific customers as per the customer demand. At the same time, we are watching the market response, especially the customer demand direction to see how much ratio we need to cover for smart dry*" (Interviewee 3, Line 85-88).

Here, container-level smart solutions are not rolled out systematically, but rather selectively, according to customer requirements and economic justification. Such findings resonate with Raza et al. (2023), who argue that adoption in maritime logistics is fragmented and uneven, shaped less by strategic visions and more by the business models and cost structures of individual companies.

The contrast with the German example was also apparent. Interviewee 4 described Germany's proactive strategy, noting:

> "*Germany's approach of making every container traceable… serves as a model for other countries*" (Interviewee 4, Line 38-39).

Furthermore, the Interviewee 6 concluded the topic of the return of investment as follows:

> "*Is there any way that I don't use IoT? If I use IoT, what is the value that I am going to get*?!" (Interviewee 6, Line 105-106).

This highlights a significant divergence that while Germany pursues fleet-wide adoption as a strategic goal, China continues to balance state ambition with market caution and reflect on the costs and demands, which might or might not justify the full fleet digitalisation.

In essence, the findings of subsection 5.4.1 on Chinese approach to digitalisation reveal that China's digitalisation of containers might reflect a strategic-operational divide: the state articulates a strong national vision of technological leadership, but market actors adopt a cautious, incremental approach guided by cost recovery and customer demand. This gap between policy rhetoric and commercial reality could illustrate how China's broader industrial digitalisation agenda, embodied in *Made in China 2025* and the Belt and Road Initiative, has not yet translated into systematic container IoT solutions deployment. Instead, adoption remains reactive rather than strategic, with companies investing selectively where immediate economic value can be demonstrated. Potentially, China's ambition to lead in digital logistics is constrained not by lack of technology, but by misaligned incentives and weak return-on-investment logic proof, a pattern that distinguishes it from coordinated transformations seen in the German counterpart. This tension underscores a central theme of the research, which focuses on China's digitalisation of maritime freight assets. The digitalisation might be visionary in narrative but cautious in execution, revealing the limits of top-down industrial policy when market rationality dominates investment behaviour.

5.4.2 Implementation Challenges: Cost, Battery, and Technical Viability

Even as digitalisation is promoted rhetorically, unresolved technical and financial challenges continue to impede large scale adoption of smart containers in China.

Interviewee 1 pointed to battery life as a critical barrier, emphasising that annual replacement is "economically unrealistic" for dry containers, where margins are far lower than in reefer operations:

> "*This year, we also conducted some trials on dry containers. However, due to the unresolved battery issue, IoT devices on dry containers can only last for about one year*" (Interviewee 1, Line 75-76).

This concern was reinforced by Interviewee 2 who identified persistent difficulties in communication reliability, power supply, and legal compliance:

> "*Now we do not have a good technical means, right?! Including the cost problem, including the problem of communication, including the core or battery problems, and so on, in the future there will be some problems with the international law*" (Interviewee 2, Lines 104-107).

However, Interviewee 2 stressed the characteristics of the return of the investment into the digitalisation technology as the decision-making influencer:

> "*This hasn't paid for itself yet! This I know, in fact, for many years we want to know the location of each container, it is inevitable, but our current technology means, I think it is difficult to say right... the current technical means, they are not good means as just said, they cannot return to the capital, right?!"* (Interviewee 2, Line 78-82).

Interviewee 4 continued and reconfirmed the cost and demand factors for the technology roll-out in China:

> "*I believe the choice of technology primarily depends on factors such as user requirements and functionality, equipment purchase and installation costs, operational costs, and supporting facilities at related terminals and storage yards*" (Interviewee 4, Line 46-49).

Interviewee 5 offered to look at the digitalisation tools which are inferior to the IoT devices however still can satisfy the track-and-trace use cases, such as QR codes and NFC tools:

> "*Regarding container digitalization, the process is underway in China, with trends moving towards using new technologies to replace simple numbering. NFC installation is costlier, but QR codes are cheaper and highly efficient*" (Interviewee 5, Line 52-55).

These issues reflect a broader trend in the literature, where economic and technical bottlenecks are identified as the primary obstacles to container-level digitalisation. Pagano et al. (2022) and Gunasekaran et al. (2017) note that without scalable solutions for energy supply and cost-effective device maintenance, track-and-trace systems struggle to demonstrate viable return on investment. From the findings it was possible to observed that unlike reefer containers, which have already established clear use cases for IoT monitoring, dry containers continue to lack compelling business cases to justify large-scale adoption.

The interviews therefore confirm that enthusiasm for the potential of digitalisation is tempered by the realities of technical durability and cost. This tension illustrates why, despite China's global role as the largest container producer, adoption at the asset level remains inconsistent and limited.

5.4.3 Standardisation: National Alignment and Global Aspirations

The interviews revealed a nuanced understanding of China's engagement with container digitalisation standards, underpinned by both ambition and fragmentation. While China is visibly active in international standardisation efforts, internal inconsistencies and incomplete harmonisation continue to limit the effective translation of participation into interoperability. Interviewees 1, 4, and 5 all referred to involvement in national and international regulatory and technical committees, confirming an institutional intent to position China as a key player in shaping the global frameworks governing smart container technologies. Interviewee 1 distinguished between two complementary dimensions of standardisation participation: engagement through professional associations that review best practices for standardisation purposes, and collaboration with regulators at both national and international levels:

> "*Our company also has a subsidiary called [Name], which works on IoT. It's one of the drafting units for several IoT-related standards. That's one part. The second part is the National Standards Committee, which is China's National Standards Committee. Through this, we also participate in ISO activities. Yes, this is another area where we're active*" (Interviewee 1, Line 188-192).

Interviewee 4 similarly framed China's participation as an exercise in international contribution and reputation building:

> "*We participate in the international ISO TC104 and China's container standardization organizations, primarily to contribute to and promote the development of relevant standards*" (Interviewee 4, Line 70-71)

Interviewee 5 provided a comprehensive overview of this multi-layered participation, noting that China's efforts span enterprise, industry, and national levels:

> "*China participates in national, industry, and enterprise standards, with ISO being the most prominent. National standards are overseen by the National Standards Committee (SAC), and container standards are managed by the Ministry of Transport's Standardization Committee. China actively engages in ISO standards to promote advanced digital and AI technologies, fostering industry development*" (Interviewee 5, Line 112-116).

Together, these accounts confirm China's aspiration to act not merely as a standard-taker but as a rule-shaper in global logistics digitalisation. Interviewee 5 further referred to the Ministry of Transport's involvement in the International Maritime Organization (IMO), emphasising that participation in international technical fora is accompanied by domestic coordination efforts:

> "*The Ministry of Transport participates in IMO standards related to maritime regulations. Containers fall under the jurisdiction of the National Container Standardization Committee. China aims to contribute to international standards, ensuring global compatibility and efficiency*" (Interviewee 5, Line 120-123).

Several interviewees identified enduring fragmentation within domestic governance. Interviewee 6 observed that "everyone pulls their own direction" (Line 374-377), describing how institutional silos and competing technological interests complicate a coherent national position. This aligns with Herold et al. (2021), who argue that digitalisation is not a linear or purely technical process but one that is socially and institutionally constructed through negotiation among multiple actors with divergent agendas:

> "*I don't know if everyone is actively involved in the in the Chinese National Committee for standards, but you could understand the Chinese group or team has particular technological interests when they speak standardisation, for example in ISO TC 104 or everyone pulls their own direction*" (Interviewee 6, Line 374-377).

Interviewee 3 introduced a more critical view, suggesting that standardisation remains a major obstacle to digitalisation in practice:

> "*If we the financial issue outside of the discussion, I think, standardisation is still a problem here at the industry. Also, the compliance. Problem for many countries*" (Interviewee 3, Line 103-106).

Interviewee 3 elaborated that a lack of international harmonisation among IoT-related standards has produced compliance uncertainty that slows deployment:

> "*...if we install a smart device onto the container sometimes it will cause some compliance problems in some countries. That's how to see an issue and unknown problem. We do not know at what level it is. A kind of a barrier to make the container digitalized and smart. I think that's one of the reasons that most of the shipping companies are watching and waiting"* (Interviewee 3, Line 113-117).

The findings from the interviews regarding China's approach to standardisation and interoperability are consistent with the conclusions drawn in Chapter Two, which identified interoperability and regulatory fragmentation as persistent barriers to maritime digitalisation (Raza et al., 2023; Manners-Bell, 2023; Herold et al., 2021). As discussed in the literature review, Internet of Things infrastructures depend on both hardware and

software layers comprising sensing, networking, service, and interface components (Birkel & Hartmann, 2020), each of which must operate seamlessly across jurisdictions and organisations. The governance of these data flows is often highly standardised within national frameworks, yet a global mechanism for harmonisation remains absent. The interview data therefore confirm what the literature anticipated: the data governance dimension of the IoT can be effectively standardised at the national level but continues to lack global interoperability, a factor that is critical for containers operating across multiple jurisdictions and technological environments. The literature further suggests that China's participation in international forums reflects its broader geopolitical ambition to move from a rule-taker to a rule-setter in global trade and digital governance (Gao, 2018; Wang, 2018; Lambrou et al., 2019). However, the empirical evidence indicates that while this ambition is evident through China's active engagement in ISO and other international bodies, its domestic ecosystem remains characterised by internal contestation and fragmented institutional coordination, which complicates its ability to present a unified position internationally.

Building on the literature's emphasis on data sovereignty (Zhang, 2024; Abbas et al., 2024), it can be inferred that one of the principal obstacles to Chinese smart container integration into the global logistics ecosystem lies in the misalignment between national data-governance standards and international expectations. The coexistence of highly codified domestic rules and the absence of universally harmonised technical protocols create uncertainty for cross-border compliance. As noted in Chapter Two, Section 2.4.1.2 China's Data Security Law and Personal Information Protection Law impose localisation and state-access requirements that may conflict with the interoperability principles embedded in global IoT frameworks such as those advocated by UN/CEFACT or ISO. Consequently, while the data governance pillar of IoT is well institutionalised within China, its translation to the international arena remains partial and asymmetrical.

Importantly, on the hardware side, the standards themselves are not yet finalised. The ISO Technical Committee 104 Subcommittee 4 Working Group 2 Technical Specification ISO TS 25287 (ISO, 2025) on smart container functionality and identification, developed to ensure interoperability and compliance among manufacturers and operators, remains under preparation and has not yet been published. This pending specification represents an expectation to define minimum requirements for hardware interoperability, data

interfaces, and performance verification of IoT-enabled containers. Until its official release or any other similar standard, manufacturers and shipping lines continue to operate within fragmented frameworks.

This situation reflects what the literature in Chapter Two described as the 'standardisation gap' in the digitalisation of maritime logistics. While the IoT ecosystem for container digitalisation is conceptually mature, the absence of harmonised technical and data standards undermines the goal of a unified, secure, and efficient smart container network. The findings of this study reaffirm that China's active participation in ISO and domestic committees demonstrates strategic ambition, but the simultaneous lack of domestic coordination and the ongoing development of ISO TS 25287 highlight that global standardisation remains a work in progress.

In conclusion, the empirical evidence shows that China's participation in international standardisation bodies supports its aspiration to transition from rule-taker to rule-setter in global digital logistics governance (Gao, 2011; Wang, 2018; Lambrou et al., 2019). However, this ambition is constrained by internal fragmentation and the unresolved harmonisation of national and international IoT standards. The data suggest that while data governance within China is heavily formalised, it does not yet align seamlessly with international interoperability requirements, an issue that is particularly acute for mobile IoT assets such as containers, which must operate across diverse legal and technological environments. As the ISO TS 25287 specification approaches completion, its publication might become a crucial determinant of whether these parallel systems can converge. Until then, the digital container ecosystem remains characterised by structured national standardisation but incomplete international harmonisation, leaving the promise of interoperable global IoT logistics only partially realised.

5.4.4 Governmental Support: Fragmented and Indirect

When asked about governmental support for container-level digitalisation, interviewees consistently emphasised that subsidies and direct financial assistance were either minimal or absent. Interviewee 1 explained that project-based support existed but was capped at levels insufficient to fund large-scale digitalisation programmes, noting:

> "*There are some subsidies, yes. But I'm not too familiar with the specifics. I have previously handled applications, though. Basically, you apply, and since it's considered a high-tech industry, the government approves the subsidy. The process is relatively easy, but the amount isn't very large, usually in the range of hundreds of thousands of RMB. For a shipping company, this amount is quite minimal*" (Interviewee 1, Line 161-165).

Interviewee 1 further elaborated by stating:

> "*For example, we're currently working with the National Standards Committee on some system promotion projects. Their funding model is like this: for each task, they can provide up to about 500,000 RMB. If a company wants to collaborate with the government on a project, the government can contribute up to 500,000 RMB, but the rest of the costs must be covered by the company. However, as long as the project is innovative, involves something that hasn't been done before, and falls under high-tech or digitalization, it's relatively easy to secure funding from the government*" (Interviewee 1, Line 166-173).

Interviewee 6 added that state support was limited to indirect fiscal measures, research and development (R&D) tax waivers:

> "*I can show you that they don't call it a subsidised, but then they have this so-called R&D component in their tax filing. So, if they can prove that they have developed a new device, or something is new that they can actually quantify this as R&D cost. It means that this cost can be waived through tax. They don't get subsidised, but they get a lot of R&D costs with a tax waiver. So indirectly they get subsidised*" (Interviewee 6, Line 419-425).

By contrast, Interviewee 3 stated unequivocally, "*No money from a government*" (Lines 378-379). Interviewee 7 summarised this paradox:

> "*Why now intelligent container development is not as fast as we expected, a big reason is that governments support the development of intelligent containers, but the container industry did not get a penny of government*

subsidies, this is precisely the industry has been more entangled place."
(Interviewee 7, Line 385-388)

These perspectives expose the discrepancy between rhetorical endorsement and material support. Although policy frameworks such as *Made in China 2025* and the Belt and Road Initiative position digitalisation as a national priority, the findings show that direct financial mobilisation at the industry level remains limited. Instead, state engagement takes the form of symbolic or indirect incentives, such as tax deductions, innovation labels, and limited project-based funding, rather than consistent capital investment.

This pattern aligns with the broader literature on China's developmental state model, which emphasises selective and strategically targeted intervention rather than uniform subsidisation. As discussed in Chapter Two, *Made in China 2025* articulates a vision of technological upgrading through fiscal incentives and strategic funds such as Government Guidance Funds, yet implementation across sectors is uneven (Luong et al., 2021; Kennedy, 2015; Zenglein & Holzmann, 2019; Naughton, 2021). The empirical evidence presented here supports these assessments: while R&D tax reliefs and project grants exist, they do not constitute a systemic funding mechanism for container-level IoT innovation. Instead, companies must self-finance large-scale deployments, relying on commercial justification and return on investment rather than state direction.

Considering Gao's (2011) and Wang's (2018) analyses, this approach can be understood as a form of *strategic conformism* in which China's government promotes high-level policy visions and international engagement but delegates operational risk and cost to enterprises. As Gao (2011) observed in the trade governance sphere, China often adopts global norms to gain legitimacy while adapting their implementation to national priorities. Similarly, Wang (2018) found that in financial standard setting, China combined compliance with selective participation to balance learning and control. The fragmented and indirect support observed here mirrors this logic: the state sustains an appearance of mobilisation through symbolic measures while maintaining fiscal prudence and strategic selectivity.

These findings also correspond with the literature's scepticism towards assumptions of uniform state mobilisation in logistics digitalisation. Cortes-Murcia et al. (2022) caution that policy ambitions in the logistics sector rarely translate into consistent structural

funding, as state resources are concentrated in manufacturing or infrastructure rather than asset-level innovation. The limited funding reported by interviewees demonstrates that container digitalisation falls outside the strategic priority areas.

Consequently, governmental stimulation of container digitalisation in China appears fragmented and indirect. This state-owned support operates more through fiscal facilitation than through industrial financing, leaving companies to determine adoption primarily through commercial rationales and anticipated returns on investment. This observation contributes to closing Gap Four identified in the literature review by confirming that, contrary to expectations derived from China's developmental state rhetoric, tax reductions and subsidies play only a marginal role in shaping smart container adoption. The evidence suggests a divergence between national strategy and sectoral execution: while the state articulates a digital transformation agenda aligned with global leadership ambitions, actual resource mobilisation within the container industry remains limited, decentralised, and largely symbolic.

5.4.5 Technology Origin

A final theme emerging from the interviews concerns the influence of technology origin on procurement decisions. Consistent with the findings in subsections 5.4.1 and 5.4.2, most interviewees emphasised that commercial considerations such as cost, functionality, and reliability outweigh the question of whether technology providers are domestic or foreign. Interviewee 4 stated:

> "*There should be no restrictions on whether the provider is domestic or international*" (Interviewee 4, Lines 56-57).

Similarly, Interviewee 6 acknowledged the growing strength of Chinese leaders such as Huawei and ZTE while maintaining that openness to international providers remains acceptable, provided they meet technical and regulatory requirements:

> "*I think for what I understand so far, they have no restriction to say that they only use a Chinese tracking device. They can use anyone, any, any tracking device so long as meet their standard of reform. And yeah, but they themselves*

> *are very strong into this tracking device technology. As you know about Huawei, ZTE or another tech*" (Interviewee 6, Line 208-212).

Some participants framed the issue in explicitly global terms Interviewee 8 (Line 200) remarked: "*It should be global because we can't confine ourselves within China*," claiming Chinese IoT solutions should be compatible with the global technology offers and compatible, where required to provide interoperability.

These perspectives indicate a pragmatic commercial orientation aligned with global integration, consistent with Lambrou et al. (2019), who argue that China's digital logistics strategy is outward facing, combining domestic capability building with international technology exchange.

However, while openness is articulated at the discursive level, actual procurement decisions reveal a preference for domestic production. Interviewee 3 explained that although cost and quality remained primary criteria, proximity and ease of management often favoured local manufacturers:

> "*Finally, we selected the manufacturer's nearby Shanghai. Not purely because of the location. But how to consider the facility?! Make it easy for management. Yeah, we must measure the quality of the manufacturing. To do the monitoring of the regulatory the compliance and so on. If the manufacturing is in overseas, then it means that we have to do a lot of travel and not easy for communication and to do this on-site check and the monitoring that's finally we selected the manufacturing factors. Nearby Shanghai: I think the approach, the pathway for such kind of decision is very similar in the in the industry. Quality and cost and how to say availability as well as the complexity of the management and control*" (Interviewee 3, Line 165-174).

This discrepancy between declared openness and practical localisation reflects what Herold et al. (2021) describe as the social construction of digitalisation in China, where narratives of global cooperation coexist with strong national industrial preferences. Such duality also mirrors the logic outlined in Chapter Two, that while China's digital transformation is embedded in global supply chains, the container digitisation process

operates within a developmental state framework that privileges domestic capacity and regulatory oversight (Kennedy, 2015; Naughton, 2021; Zenglein & Holzmann, 2019).

In this context, the preference for domestically produced IoT devices aligns with the *Made in China 2025* emphasis on technological sovereignty and strategic self-reliance. As discussed in Chapter Two, MIC 2025 encourages selective openness, welcoming global collaboration where it enhances innovation capacity but reinforcing domestic sourcing when strategic technologies or data control are at stake (Boullenois et al., 2025). The pragmatic preference for Chinese-made devices thus reflects not protectionism but an institutionalised form of strategic selectivity: a balancing of market logic with the imperatives of national industrial and data security policy.

The literature further supports this interpretation through the lens of data sovereignty and governance. As shown in Chapter Two, China's Data Security Law (DSL) and Personal Information Protection Law (PIPL) emphasise localisation and state access provisions that may indirectly discourage the use of foreign IoT equipment in sensitive sectors (Zhang, 2024). For companies operating in logistics, domestically manufactured hardware ensures regulatory compliance and reduces exposure to scrutiny over cross-border data flows. The preference for local suppliers therefore arises not only from cost and convenience considerations but also from the need to align with national legal frameworks that treat industrial data as a sovereign asset rather than a purely commercial one.

This finding also echoes institutional theory perspectives discussed in the literature review. As Scott (2014) suggests, organisational choices in highly regulated environments are shaped by coercive and normative pressures rather than purely by efficiency considerations. In the case of China's smart container ecosystem, companies navigate a regulatory landscape in which institutional legitimacy depends on adherence to state-defined technological and data governance standards. Consequently, procurement decisions that appear commercially pragmatic are also institutionally rational, ensuring alignment with evolving national policy and regulatory expectations.

In summary, while interviewees articulated an open and global outlook on technology sourcing, practical decisions reveal a pattern of domestically anchored procurement influenced by proximity, governance alignment, and strategic trust. This duality mirrors

the broader dynamics of China's digitalisation trajectory described in Chapter Two, where *Made in China 2025* promotes outward integration while reinforcing inward control. The empirical evidence therefore reinforces the literature's depiction of Chinese digitalisation as a hybrid process, global in discourse yet nationally embedded in practice, reflecting the interplay between technological pragmatism, institutional conformity, and developmental state logic.

5.4.6 Identified Patterns in Findings on Data Governance and Sovereignty

The patterns emerging from the interviews reveal a complex and at times contradictory configuration of state ambition, market pragmatism, and institutional fragmentation. Together, these patterns in findings illustrate how China's approach to container digitalisation oscillates between alignment with theoretical expectations derived from the developmental state model and divergence shaped by sectoral and economic constraints.

The first pattern reflects a strong alignment between national strategic visions and the narratives articulated by industry actors. Interviewees repeatedly referenced *Made in China 2025* and the Belt and Road Initiative (BRI) as overarching frameworks guiding digital transformation in logistics. These views echo Lu and Chi (2019) and Manners-Bell (2023), who describe China's pursuit of technological leadership as inseparable from its broader political-economic agenda. Interviewees also highlighted the significance of institutional participation, with several referring to involvement in international technical committees such as ISO TC 104. This supports Herold et al.'s (2021) conceptualisation of digitalisation as a socially and institutionally constructed process through which China seeks legitimacy and influence by embedding itself in global standardisation forums. Such engagement aligns with Gao's (2011) and Wang's (2018) analyses of China's transition from a rule-taker to a rule-maker in trade and financial governance, achieved through incremental adaptation and selective norm shaping.

A further point of alignment concerned attitudes towards international collaboration. Interviewees such as Interviewee 4 (Lines 54-55) affirmed that "*there should be no restrictions on whether the provider is domestic or international*," signalling a pragmatic commitment to functionality and performance over technological nationalism. This perspective corroborates Lambrou et al. (2019) and Voorspuij and Becha (2021), who

describe China's logistics innovation as outward-facing and commercially rational rather than protectionist. Such pragmatism also resonates with the literature on strategic conformism, where China adopts global norms to secure legitimacy while selectively integrating them with national objectives (Gao, 2011; Wang, 2018).

However, the findings also expose clear contradictions that complicate the narrative of a uniformly mobilised developmental state. Interviewees consistently reported minimal or inconsistent governmental subsidies for container level digitalisation. Interviewee 3 (Lines 378-379) stated unequivocally that there was "*no money from government*," while Interviewee 7 described the paradox of rhetorical support without material funding:

> *"The first one is the digitisation of containers, which is always supported by the Chinese government. My understanding ah, not only the Chinese government support, including my understanding of Singapore, Malaysia, South Korea, they are very supportive, because we can see that through the development of intelligence can improve efficiency and security. This is no problem. Then, the second, why now intelligent container development is not as fast as we expected, a big reason is that governments support the development of intelligent containers, but the container industry did not get a penny of government subsidies, this is precisely the industry has been more entangled place"* (Interviewee 7, Line 380-388).

These observations diverge from expectations in the literature that portray the Chinese state as a consistent financier of industrial modernisation (State Council, 2015; Yu, 2024). As discussed in Chapter Two, *Made in China 2025* was designed as a strategic innovation policy, but its implementation has been highly selective and decentralised. The limited and symbolic nature of subsidies observed in the container sector supports Kennedy's (2015), Zenglein and Holzmann's (2019), and Naughton's (2021) conclusion that MIC 2025 operates less as a monolithic industrial plan and more as a flexible governance framework characterised by uneven sectoral prioritisation and fragmented funding channels. The pattern of indirect fiscal incentives and project-based grants reported by interviewees thus reflects what Naughton (2021) terms "guided market capitalism," in which the state provides strategic direction but delegates operational risk to enterprises.

A second area of divergence concerns the focus of digitalisation. Interviewees consistently observed that investment and policy attention concentrate on ports and large infrastructure nodes rather than on container IoT technologies. This contrasts with global discourses that present asset level visibility as a prerequisite for resilient and transparent supply chains (Raza et al., 2023; UN ECE, 2019). The finding confirms Cortes-Murcia et al.'s (2022) argument that Chinese logistics innovation is shaped by fragmented implementation and uneven institutional coordination. Cortes-Murcia et al. (2022) argument also reflects the pattern of sectoral hierarchy identified in Chapter Two, where industries aligned with national security and export competitiveness receive sustained support, while peripheral sectors such as maritime equipment and container IoT rely more heavily on market demand.

The interviews also revealed ambivalent patterns, where rhetorical alignment with state strategy coexists with practical constraints and selective adoption. Manufacturers and technology developers portrayed themselves as technologically capable and aligned with state innovation priorities, while operators described digitalisation decisions as contingent upon customer demand and cost recovery. Interviewee 3 (Lines 85-88) highlighted that smart container deployment remains limited to "*specific customers as per the customer demand*," underscoring the predominance of commercial logic. This tension between policy discourse and operational pragmatism reflects Cortes-Murcia et al.'s (2022) observation that China's logistics modernisation is shaped less by central direction than by company level rationality and economic feasibility.

Ambivalence also emerged in discussions of technology origin. While interviewees publicly endorsed openness to international suppliers, several acknowledged a practical preference for domestic manufacturers, citing cost, oversight, and regulatory compliance advantages. Interviewee 3 (Lines 165-172) stated that "the deployed IoT on Chinese containers is mainly made in China," reinforcing findings from Section 5.4.5 that domestic technology and component sourcing offers practical efficiencies and aligns with data localisation requirements. This duality reflects Herold et al.'s (2021) concept of pragmatic globalism, where companies embrace global integration discursively but rely on national ecosystems in practice. This finding also mirrors the developmental state logic described in Chapter Two, where technological sovereignty and data governance,

enshrined in the Data Security Law (DSL) and the Personal Information Protection Law (PIPL), shape industrial choices even when market openness is rhetorically maintained.

Taken together, these findings reveal a hybrid model of Chinese digitalisation: strategically ambitious, institutionally active, and globally engaged, yet constrained by fragmented implementation, economic caution, and sectoral asymmetry. The evidence validates elements of the developmental-state study and institutional theory, particularly the state's role in setting strategic direction and legitimising technological modernisation but also challenges assumptions of cohesive mobilisation. Instead, the Chinese model of container digitalisation emerges as an expression of selective state capitalism (Naughton, 2021), a configuration in which policy vision, institutional participation, and market rationality interact dynamically but unevenly. This hybrid approach confirms that while China aspires to shape the global digital logistics order through initiatives such as MIC 2025 and the BRI, its capacity to do so remains moderated by financial pragmatism, institutional fragmentation, and the enduring influence of market-based decision-making.

5.4.7 Summary of Governmental Stimulation of the Chinese Smart Container

The empirical evidence reveals that China's approach to container digitalisation is characterised by a persistent tension between national ambition and practical implementation. On the one hand, strategic visions articulated in *Made in China 2025* and the Belt and Road Initiative promote a narrative of digital leadership and technological modernisation, a narrative echoed in interviewee accounts and reflected in China's active participation in international standardisation bodies such as ISO TC 104. These findings align with academic claims that China seeks to move from being a rule-taker to a rule-setter in global governance, as argued by Gao and by Wang, and with analyses that link digitalisation to institutional discourse and rule-making (Gao, 2011; Wang, 2018; Lambrou et al., 2019; Manners-Bell, 2023; Herold et al., 2021). The emphasis on engagement in standardisation forums indicates a commitment to embedding Chinese technological priorities in international frameworks, although domestic coordination remains uneven.

At the same time, the interviews make clear that operational realities diverge from these strategic narratives. Implementation of smart container technologies is cautious,

fragmented, and primarily market driven. Several interviewees described container-level adoption as dependent on specific customer demand rather than as a systemic objective, while others emphasised unresolved technical challenges concerning battery life, power supply, and communication reliability. These findings reinforce the observation in the literature that dry container digitalisation struggles to establish a scalable business case, in contrast to the clearer value proposition for refrigerated containers, and that companies proceed only where returns can be justified (Raza et al., 2023).

Governmental support was described as indirect, inconsistent, and largely symbolic. Interviewees acknowledged capped project grants and R&D tax waivers but consistently denied the availability of structural subsidies for smart container deployment. This gap between rhetorical endorsement and financial mobilisation directly addresses the literature review's Gap Four by confirming that tax reductions and subsidies have not played a decisive role in stimulating adoption. The findings on governmental support also qualify expectations derived from developmental state interpretations that presume strong and uniform resource mobilisation across strategic sectors and instead aligns with literature that portrays *Made in China 2025* as a decentralised, selective, and financially mediated policy architecture whose benefits accrue unevenly across industries.

A further layer of ambivalence concerns technology origin. Across companies, interviewees stressed that functional suitability, cost, and performance outweighed questions of whether technology was domestic or foreign, which accords with depictions of pragmatic globalism in Chinese logistics. Yet the acknowledgement that most deployed devices on Chinese containers are domestically produced suggests a practical bias toward local solutions, driven by cost control, supplier proximity, oversight, and alignment with data governance requirements. This discrepancy between rhetorical openness and procurement practice helps close Gap Three by clarifying that China's alignment with international practices is partial and tempered by national priorities, data sovereignty concerns, and institutional trust.

Standardisation emerged as both a channel of influence and a bottleneck to scale. Active participation in ISO TC 104 and related bodies sits alongside fragmented domestic coordination and incomplete harmonisation between national and international rules. Interviewees pointed to compliance uncertainty across jurisdictions and to the absence of

a published, widely adopted hardware specification for smart containers, noting that the ISO TC 104 SC 4 WG 2 technical specification remains pending. This situation is consistent with the literature's account of a standardisation gap in maritime digitalisation, where national data governance frameworks are well defined but global interoperability remains unresolved, particularly for mobile assets that traverse multiple legal and technical environments.

5.5 Summary and Conclusion of the Findings

This chapter presented the empirical findings addressing the three research questions and the corresponding gaps identified in Chapter Two. The evidence drawn from the interviews illustrated that China's approach to container digitalisation constituted a hybrid configuration of state direction, market pragmatism, and institutional negotiation. Across the three domains analysed, namely market penetration, data governance, and governmental stimulation, China's digitalisation strategy appears strategically ambitious and internationally engaged but operationally fragmented and economically selective.

Research Question One explored the Chinese approach towards using track-and-trace technology for shipping containers. The findings revealed that the adoption of track-and-trace technology on Chinese owned containers was progressing yet remained uneven and primarily driven by market logic. Chinese shipping companies and operators did not pursue digitalisation as part of broader corporate transformation agendas aligned with national visions such as *Made in China 2025* and the Belt and Road Initiative, but rather based on the customer demand and in a relatively cautious way, reluctance due to cost, technical maturity, and uncertain returns on investment while Chinese leasing companies and smaller actors displayed reluctance lack of customer request for such service. This selective uptake confirmed that China's transition towards smart containerisation followed an incremental, demand driven trajectory rather than a uniform, state-mobilised one. The empirical results therefore closed *Gap One* by providing detailed, field-based insights into how Chinese companies interpret and implement container-level digitalisation within broader supply chain strategies.

Research Question Two investigated the Chinese perspective on data ownership and sharing in the digitised supply chain. The findings demonstrated that China's data

governance regime was characterised by contractual ownership logic nested within a statist sovereignty framework. Data was treated as a strategic resource governed by the Data Security Law and the Personal Information Protection Law, with ownership assigned to the entity financing collection but sharing restricted by confidentiality and national security concerns. Although interviewees acknowledged conditional openness under contractual or international arrangements, in practice data sharing remains cautious, reflecting institutionalised mistrust and protective commercial behaviour. This outcome closed *Gap Two* by offering empirical confirmation that cybersecurity and sovereignty considerations substantially limit cross-border data exchange and interoperability, even as China participates actively in international standardisation and promotes the rhetoric of openness through initiatives such as the Digital Silk Road.

Research Question Three addressed the potential influence of Chinese smart containers. Findings related to this question indicated that governmental stimulation of smart container adoption, which could increase the Chinese smart container influence on the domestic and thereafter the global market, was indirect and fragmented, thereby constraining the container digitalisation's broader transformative role. Interviewees described the availability of limited project-based funding and research and development tax waivers but consistently denied large scale subsidies or targeted financial assistance. Consequently, companies claimed to rely primarily on self-financing and market-driven decision - making, with digitalisation concentrated in high-value segments such as ports and logistics hubs rather than at the container asset level. This pattern supported the interpretation that *Made in China 2025* functions as a framework for strategic signalling rather than a mechanism of comprehensive fiscal mobilisation. The evidence thus closed *Gaps Three and Four* by clarifying both the limited alignment of Chinese governance with international digitalisation frameworks and the absence of substantial government funding as a catalyst for adoption.

Across all themes, three integrative insights emerged. First, China's approach to smart container reflected the developmental state logic of strategic steering without full-scale intervention. The state articulated direction through policy and international engagement, while enterprises retained autonomy over commercial execution. Second, institutional participation in global standardisation served as a key vector of influence, allowing China to shape emerging norms while maintaining domestic discretion. Third, despite rhetorical

commitment to openness and global collaboration, implementation remained constrained by technical, financial, and regulatory asymmetries that slow the transition from ambition to scale.

Overall, Chapter Five demonstrated that China's smart container ecosystem exemplified a hybrid model of digital transformation: globally engaged yet domestically cautious, technologically capable yet commercially selective, and strategically visionary yet pragmatically constrained. This synthesis provided the empirical foundation for the subsequent discussion chapter, which interprets these findings through the theoretical frameworks of the developmental state, strategic industrial policy, institutional theory, and data governance and sovereignty, evaluating how China's evolving digitalisation practices contribute to or diverge from international norms in global logistics.

This chapter has examined the empirical dimensions of China's container digitalisation, revealing a pattern of selective adoption shaped by the interaction of state strategy, market incentives, and institutional coordination. The findings confirmed that while digitalisation is embedded in national visions such as *Made in China 2025* and the Belt and Road Initiative*,* its implementation at the container level remains uneven, primarily governed by commercial rationale and constrained by cost, technical maturity, and regulatory fragmentation.

Three overarching conclusions can be drawn. Firstly, the China's smart container adoption reflects a developmental state model tempered by market pragmatism: government sets strategic direction and engages in international rulemaking, yet enterprises retain autonomy in investment and deployment. Secondly, data governance practices reveal a sovereignty-centred but contractually flexible regime that balances protectionism with conditional openness, confirming that data are treated simultaneously as strategic and commercial assets. Thirdly, governmental stimulation of container digitalisation is largely indirect, relying on tax incentives, project-based funding, and standardisation initiatives rather than systematic subsidies or fiscal mobilisation.

The chapter therefore demonstrated that China's path towards container digitalisation was both globally connected and domestically cautious. Its institutions actively participated in international standardisation and policy discourse, yet domestic implementation continued to be mediated by fragmented coordination and the economic realities of the logistics industry. These insights provided the empirical basis for Chapter Six, which

interprets the findings through the theoretical frameworks of the developmental state, strategic industrial policy, institutional theory, and data sovereignty, assessing how China's evolving digital practices reshape its position in global logistics governance.

6 Discussion of the Chinese Smart Container Development

6.1 Framing the Discussion and Analytical Structure

This chapter interprets the empirical findings presented in Chapter Five through the theoretical and conceptual frameworks outlined in Chapter Three. Its purpose is to explain how the Chinese approach to container digitalisation reflects the interaction between state ambition, market rationality and institutional structure. By situating the findings within developmental state theory, TOE, institutional theory and the data governance and sovereignty model, the chapter provides an integrated account of the mechanisms that shape China's trajectory of container digitalisation.

The chapter follows the structure of the three research questions. The first thematic section 6.2 examines how Chinese actors use track-and-trace technology at the container level and addresses *Research Question One*. The following section 6.3 explores the Chinese perspective on data governance in the digitised supply chain and answers *Research Question Two*. Section 6.4 considers the potential influence of Chinese smart container development and responds to *Research Question Three*. Each thematic discussion synthesises empirical evidence with theoretical interpretation to identify the underlying patterns that connect governance, industrial strategy and technological practice.

Before turning to these thematic analyses, it is necessary to establish the reliability of the qualitative interpretation. Intercoder reliability provides assurance that the analytical themes presented in this chapter are grounded in a consistent and transparent coding process rather than the subjective inclination of a single researcher. Krippendorff's alpha was selected as the reliability coefficient because of its suitability for different data types, its ability to account for partial agreement and its stronger correction for chance compared

with Cohen's kappa (Krippendorff, 2018; Hayes & Krippendorff, 2007; ATLAS.ti, 2024; Lombard et al., 2002).

The reliability assessment was conducted using the original Chinese-language transcripts and involved the principal researcher and Ms YinYing Kong, a native Chinese speaker. This procedure was essential because meaning in the data is embedded in linguistic, cultural and institutional context. Both coders applied the same established codebook, and the coding was carried out independently. The resulting Krippendorff's alpha of 0.616 indicated a moderate level of agreement, which is acceptable for exploratory qualitative research and for complex multilingual data (Krippendorff, 2018). This level of convergence demonstrated that coding decisions reflected shared interpretive logic rather than arbitrary or language-specific variation.

Establishing intercoder reliability strengthened the dependability and confirmability of the subsequent thematic interpretation in line with Lincoln and Guba's (1985) criteria for qualitative rigour. The ICR verified that the empirical material had been handled consistently and that the analytical themes discussed in this chapter rest upon a transparent and replicable process of interpretation. With reliability established, the chapter turns to the thematic analysis structured around the three research questions.

6.2 Smart Container Market Penetration and its Influence on the Supply Chain

This section is focused on the empirical findings on smart container adoption in China in relation to *Research Question One* as to *what is the Chinese approach towards using track-and-trace technology for shipping containers?* In addressing this question, the intention is to address the first research gap, which was the absence of detailed academic research on adoption dynamics and the influence of IoT-enabled container digitalisation on the supply chain.

The findings on smart container market penetration and its influence on the supply chain reveal a hybrid pattern of strategic commitment and operational fragmentation in China's digitalisation landscape. The data indicate that while shipping lines and large operators increasingly perceive IoT-based tracking as a strategic necessity, leasing companies

remain hesitant, underscoring the asymmetry of adoption across ownership categories. This divergence reflects a broader dynamic captured by the Developmental State Theory wherein state-endorsed strategic ambitions coexist with market-driven selectivity in implementation. Within the framework of Strategic Industrial Policy, such asymmetry illustrates how policy objectives for technological upgrading encounter heterogeneous organisational capacities and incentives. Furthermore, the persistent challenges of interoperability and compliance, as reported by several interviewees, connect to the Data Governance and Sovereignty Framework by highlighting tensions between global standardisation and domestic regulatory boundaries. From an Institutional Theory perspective, the findings underscore that digitalisation in the container sector is not merely a technological process, but a socially embedded transformation shaped by normative expectations, regulatory systems, and inter-organisational coordination. Together, these insights suggest that China's approach to container digitalisation is strategically aligned yet institutionally contingent, an interplay that will be further discussed in the following sections.

The demonstrated that Chinese companies increasingly frame container digitalisation as a strategically important process. Interview evidence confirmed a "strategic focus" on digitalisation following changes in company leadership and a shift towards a broader corporate transformation agenda. This outcome supported the argument of Herold et al. (2021) that digitalisation was socially and institutionally embedded rather than was simply a matter of technological availability. The prominence of digitalisation in corporate rhetoric reflected a strong strategic alignment, suggesting that the Chinese approach began with high-level endorsement at the organisational level.

Despite the potential expectation to see China as a leader in container digitalisation, similarly as it is already a leader in container manufacturing (World Cargo News, 2025; Sarmmah & Munroe, 2025), adoption remains partial. The findings indicated that the industry was moving beyond pilots towards operational roll-out. However, there was no indication how fast Chinese container owners are planning to go with the smart container deployment. This uncertainty was seen with one perspective indicating that part of the ownership has no fundamental interest in the smart container, which highlighted a structural divide between operators and lessors. This divergence reflected ownership and incentive asymmetries, with operators able to internalise operational benefits such as

enhanced visibility, while lessors often externalised these benefits and perceived additional risks. The outcome of the study further showed that as the devices potentially were becoming affordable and necessary, yet adoption decisions were still contingent on perceived utility, with the Chinese shipping company approving full container fleet digitalisation (China COSCO Shipping Corporation Limited, 2024; then confirmed by Interviewee 1). This asymmetry explains why falling costs of the IoT technology alone have not led to uniform deployment of the smart containers and illustrated how the Chinese approach is selective and actor specific rather than universal. It could be concluded that the interviews showed the Chinese approach being selective and actor specific: container owners who were also container operators adopted, and lessors resisted, there was no one strategy across the owners.

The technology-organisation-environment (TOE) framework helps to situate these findings of the decision asymmetry. The technological dimension of the TOE framework related to smart containers was satisfied, with affordable devices and new possibilities for artificial intelligence-based inspection, despite some concerns related to the technology maturity, and international collaboration among the stakeholders. The TOE's organisational dimension was evident in the strategic framing of digitalisation by corporate leaders. The framework's environmental dimension was reflected in assumed customer demands for visibility and the wider emphasis on resilience after global supply chain disruptions. This demand was assumed through the comments on customers data ownership, showing that there was a call for container digitalisation. Therefore, it could be expected, the Chinese smart container to move forward and the spread of the IoT technology for container digitalisation among the Chinese owned container to proceed fast. But, at the same time no interviewee has directly claimed the high and proven demand from the customer side for all types of containers. With the assumption of the environmental dimension exists, TOE does not fully capture the observed asymmetry between operators and lessors. The Chinese case suggests that TOE should be extended to incorporate value capture and incentive alignment as critical determinants of adoption. This study therefore contributed theoretically by proposing that in asset-intensive industries adoption depends not only on readiness and external pressure, such as performance of the industry competitors or availability of the technology on the market but also on whether actors are able to appropriate sufficient benefits to justify investment.

While the literature positions Industry 4.0 as a systemic integration of cyber-physical systems and real-time data exchange (Schwab, 2017; Ghobakhloo et al., 2023), the findings of this study reveal that such integration is fundamentally disrupted by ownership structures. Although Raza et al. (2023) identified a persistent "digital divide" within maritime transport, this research extends that concept by demonstrating that the divide is not simply a matter of technological access but of asymmetrical incentive alignment. The data indicates that while operators treat digitalisation as an operational necessity to create a "digital twin" of the supply chain (Ivanov, 2021), leasing companies, who control approximately 50% of the fleet, exhibit profound reluctance due to a lack of fundamental interest in the asset's data. This finding contributes to the literature by refining the TOE framework, suggesting that the "environmental dimension" (Tornatzky & Fleischer, 1990) must account for internal value-capture mechanisms that determine whether an actor adopts or resists innovation.

Institutional and regulatory factors further constrained adoption. The raised issue of the compliance challenged when mounting devices on ISO regulated containers, noting that in some jurisdictions the addition of devices could cause regulatory conflicts echoes Bumann and Peter (2019) and Lind et al. (2021), who highlighted the tension between innovation and regulation in highly standardised sectors, such as international maritime transportation. Noting the facts, that two international shipping lines, Hapag Lloyd and ZIM with the total fleet size of over three million containers together started to deploy full fleet digitalisation without reporting on compliance challenges. Since those boxes are in the operations since 2022, it could be assumed a certain disadvantage for China in comparison with its global partners within the regulatory bodies. The fact that China did not join the partners at the same scale, claiming regulatory misalignment resulted in adoption characterised by regulatory fragmentation, which generates transaction costs and slows diffusion. While Chinese companies were active in international standardisation bodies, signalling openness and alignment with global agendas, the domestic reality seemed to be more cautious. This duality reflects what may be described as pragmatic globalism, in which China seeks legitimacy in international forums while retaining sovereignty and control at home over the decisions on technology deployment.

The developmental state theory provided a further layer of interpretation. Policies such as *Made in China 2025* and Digital Silk Road signal national ambition and provide a

narrative of digitalisation as a strategic priority. However, interviewees indicated that financial mobilisation at the operational level remains limited, stressing company-led initiatives rather than state-funded programmes. This suggests that while the state sets the agenda, the PRC does not intervene strongly in shaping adoption incentives at the company level. Even with the reported tax deduction for Chinese companies (Yu, 2024) and existing Government Guidance Funds (Luong et al., 2021), the Chinese smart container project was not too successful in state funds raising. However, it was clearly seen that in case the digitalisation of the cargo boxes would ramp up in China, the process would be dominated by the domestic providers, disadvantaging foreign competitors. This would support Wübbeke et al.'s (2016) prediction of the acceleration of the local innovation by 2025, but with a delayed timeline, due to immaturity of the commercial factors. Therefore, the Chinese approach is therefore characterised by state-led signalling but commercially driven implementation, resulting in ambition without full mobilisation.

Data governance also plays an important role and will be discussed deeper in Section 6.3. However, it is important for the understanding of the Chinese smart container market penetration to look in general terms on the data governance strategy. Several interviewees expressed concerns about data sharing and expressed two supporting positions on data sharing describing that lessors often refuse access to device data to avoid contractual disadvantages, hinting that the use of the smart containers was actually happening and they were in active lease. The expressed need for international collaboration and standardised protocols confirmed the fact that the Chinese smart container project is operational but suffer from the unclarity on the data governance. This data sharing challenge could be firstly, a result of a limited number of smart containers in operation contributing to the regulatory precedent, and secondly could reflect a hybrid governance model, which got shaped through the existing cases in which contractual arrangements define ownership, regulatory frameworks reinforce sovereignty, and commercial actors limit sharing due to mistrust. The result is that collaborative business models are underdeveloped, further constraining the prospects of large-scale diffusion.

These dynamics suggested that the Chinese approach towards track-and-trace technology was defined by rhetorical commitment, selective adoption, and cautious implementation. Adoption advanced most rapidly where actors such as operators internalise benefits, particularly in high-value or strategically important corridors, while other actors such as

lessors remain reluctant. The prospects for broader penetration therefore remain contingent upon regulatory harmonisation, contractual innovation, and the creation of trusted mechanisms for data governance.

This interpretation confirmed the significance of Gap One. Whereas professional literature often referenced initiatives such as COSCO's BoxPlus (BoxPlus, 2025), the reviewed sources rarely provided detailed empirical accounts of adoption or its consequences. The present study contributed to filling this gap by showing how adoption was uneven, shaped by ownership structures, institutional pressures, and regulatory fragmentation. This research extended the TOE framework, nuanced developmental state theory by showing that policy direction has not automatically translated into mobilisation and demonstrated how pragmatic globalism frames China's international engagement while constraining domestic practice.

The interpretation of the Chinese approach must also be situated within wider national strategies, notably *Made in China 2025* and the Belt and Road Initiative (BRI). Although these frameworks were not explicitly mentioned by interviewees, they provide the policy environment in which corporate digitalisation efforts such as COSCO's BoxPlus are positioned. The Digital Silk Road, a component of the BRI, explicitly promotes the export of Chinese digital platforms and standards (Al Shaher et al., 2023), and container digitalisation can be understood as one manifestation of this ambition. This helps explain why smart container adoption in China was frequently presented in aspirational and policy-driven terms, even when detailed operational outcomes were not disclosed.

In conclusion, the Chinese approach to track-and-trace technology is strategically affirmative but commercially selective. This strategy combines strong narratives of digital transformation with practical hesitancy rooted in ownership divides, regulatory complexity, and mistrust over data. This approach ensures that adoption continues to progress, but at a measured pace that reflects structural and institutional realities rather than purely technological readiness.

The Chinese approach to smart container adoption contrasts sharply with documented international examples, most notably the fleet-wide rollouts undertaken by Hapag-Lloyd and ZIM. Hapag-Lloyd's collaboration with IoT service providers, Nexxiot and

Orbcomm (Bruno, 2022) led to the digitalisation of its entire dry container fleet of 1.6 million units, while ZIM has also committed to complete fleet coverage, supported by IoT service provider Hoopo (Uliel-Mirkin, 2024). These cases were consistently referenced in professional literature, predicting digitalisation outcomes, such as estimated time of arrival accuracy, enhanced cargo security, which would affect the end customer and the quality of the provided shipping service, as well as more efficient asset management.

In contrast, Chinese initiatives such as COSCO's BoxPlus were frequently described in aspirational or policy-driven terms. COSCO has announced that 100,000 reefer containers have been digitised (China COSCO Shipping Corporation Limited, 2024), yet there was no equivalent transparency regarding the scale of dry container adoption, which constitutes the majority of global fleets. Furthermore, unlike Hapag-Lloyd and ZIM, there were no published third-party case studies or independent assessments that evaluate the potential benefits of improved operational performance or economic outcomes of Chinese smart container programmes. This absence of verifiable evidence reflects the transparency gap already identified in the literature and confirmed by interview data.

The interviews reinforced this pattern of lack of transparency on the smart container adoption scale. While Chinese operators and corporate leaders strongly endorsed digitalisation. The findings indicate that adoption remains uneven, with a significant share of container ownership showing little incentive to invest in track-and-trace solutions. At the same time, there is evidence that adoption is moving beyond pilot projects and entering practical deployment. However, the absence of systematic and transparent reporting makes it difficult to assess the extent of this progress. Consequently, while the Chinese approach mirrors international cases in its rhetoric and ambition, it diverges in terms of transparency and measurable outcomes, independent validation, and consistency of implementation. Potentially, the Chinese container owners and IoT service providers wait to learn more from the progressing in full fleet digitalisation Hapag Lloyd and ZIM and will not stand in line of the smart container pioneers. This reflects the technology-organisation-environment framework, which emphasises organisational alignment as a critical determinant of technology diffusion.

This comparison highlighted that the Chinese approach is strategically affirmative but cautious in operational terms. This finding confirmed Gap One by showing that while professional and policy-oriented sources emphasise China's importance as a shipping and manufacturing power, they do not document adoption outcomes in the same depth as in international cases. This absence of empirical detail represents a critical shortcoming in the literature, which this study addresses by presenting evidence of how adoption is shaped by ownership divides, institutional pragmatism, and regulatory constraints.

The evidence presented in this subchapter provided a nuanced answer to *Research Question One* as to *what is the Chinese approach towards using track-and-trace technology for shipping containers?* The findings suggested that the Chinese approach is strategically affirmative, as digitalisation is consistently framed by corporate leaders as an organisational priority and endorsed in national policy narratives. At the same time, adoption remains commercially selective and structurally uneven. Some large shipping companies have already embraced smart containers, seeing them as indispensable for fleet management and supply chain visibility, while leasing companies remain resistant even when devices are affordable. This asymmetry revealed that the Chinese approach is contingent upon ownership structures, incentive alignment, and the ability of individual actors to internalise benefits.

Notably, interviewees did not reference national policy frameworks such as *Made in China 2025* or the Belt and Road Initiative. This silence indicated that, at the operational and managerial level, adoption decisions were not articulated in relation to state-led narratives but rather in terms of immediate business value and competitive necessity. Within the TOE framework, this highlighted that the environmental dimension of adoption, when the Chinese smart container deployment would grow, would be shaped more by customer expectations for visibility, by supply chain resilience pressures, and by global interoperability concerns than by national industrial strategies. From an analytical perspective, this suggested that while policy frameworks may provide high-level signalling, they are not internalised as decisive factors in day-to-day adoption choices.

This study confirmed the significance of Gap One by showing that while professional literature highlights China's role as both the world's largest container manufacturer and a dominant maritime power, it does not provide detailed empirical analysis of adoption

outcomes. Unlike international cases such as Hapag-Lloyd and ZIM, where full fleet digitalisation has been transparently documented and independently assessed, Chinese initiatives such as COSCO's BoxPlus are discussed primarily in aspirational or policy-driven terms. The absence of transparent data or third-party evaluation has left the academic literature unable to assess the scale, effectiveness, or consequences of these initiatives. By presenting interview-based evidence, this research contributed new empirical insights that demonstrated how adoption in China was shaped by commercial hesitancy, regulatory fragmentation, and conditional approaches to data governance.

Theoretically, the Chinese approach illustrated the limitations of applying the technology-organisation-environment framework in its original form. While the technological, organisational, and environmental dimensions are clearly evident, the findings show that adoption is not guaranteed unless the distribution of costs and benefits is favourable. This study therefore proposed an extension of the framework to include value capture and incentive alignment as essential determinants of diffusion in asset-heavy and globally regulated industries. The findings also refined developmental state theory by showing that the state was effective at setting agendas and signalling priorities, but less effective at mobilising adoption where commercial incentives remain misaligned. Finally, the study demonstrated how pragmatic globalism shapes Chinese digitalisation: companies engage actively in international standards to secure legitimacy but remain cautious in domestic implementation, balancing openness with sovereignty.

Practically, the analysis indicated that broader diffusion of smart containers in China would depend on contractual innovation that aligns incentives between lessors and operators, on the development of trusted and neutral mechanisms for data governance, and on regulatory harmonisation that reduces compliance uncertainties. Without these enablers, adoption would remain uneven and concentrated in selected actors and trade lanes.

In conclusion, the Chinese approach towards track-and-trace technology for shipping containers could be described as ambitious in narrative, selective in practice, and pragmatic in institutional orientation. The absence of explicit reference by interviewees to national strategies such as BRI or *Made in China 2025* reinforced the interpretation that adoption decisions are primarily shaped by commercial logics rather than direct

policy drivers. This distinguished the Chinese approach from more transparent and comprehensive international examples and highlighted the need for further systematic research on how adoption trajectories unfold in different regulatory and commercial environments. The study thus contributed to filling a critical gap in the literature, while offering theoretical refinements and practical insights into the conditions under which smart container may advance.

6.3 Data Governance and Sovereignty

The findings on data governance, presented in Section 5.3, reveal a nuanced and context-dependent Chinese perspective situated within a hybrid governance regime that integrates contractual logics at the firm level with sovereignty-oriented control at the national level. While contractual logic governs most data relations, concerns about trade secrets, competitive advantage, and regulatory compliance significantly restrict openness. This dual structure illustrates how China's approach operates simultaneously within market-based and state-driven frameworks, offering important insight into *Research Question Two* and contributing to the closure of Gap Two identified in Chapter Two. This discussion interprets these findings through the Data Governance and Sovereignty Framework and Institutional Theory, examining how China's model of data management in the digital supply chain reflects a sovereignty-preserving yet commercially adaptive system**.** Rather than reiterating the existing debate, the section demonstrated how empirical evidence confirmed, extended, and in some cases challenged theoretical assumptions concerning data ownership, trust, and state influence in cross-border digital ecosystems.

From the perspective of data governance theory, the Chinese case illustrated how contractual allocation of ownership, as emphasised by interviewees, did not operate independently but within the parameters of state law. The repeated affirmation that "data belongs to the end user" reflected Offor's (2020) contractual model, but its embedding within the regulatory framework of the PRC's Data Security Law (DSL) and the Personal Information Protection Law (PIPL) situated it in a wider statist order (Zhang, 2024). In this sense, contractual practices served as the visible layer of a system that ultimately remains sovereignty driven. This could mean that even when companies appear to control

their own data, the state retains the decisive authority, which limits genuine contractual autonomy and complicates prospects for international interoperability.

The sources identify a sharp divergence between Western contractual autonomy and China's state-centric legal framework, defined by the Data Security Law (2021) and Personal Information Protection Law (2021) (Abbas et al., 2024; Zhang, 2024). However, the findings extend the theory of "elastic sovereignty" (Vatanparast, 2020; Mueller, 2020) by identifying "commercial mistrust" as a horizontal enactment of sovereignty. While the state asserts vertical authority through regulation, companies actively enact sovereignty by withholding data to defend competitive bargaining positions. This insight contributes to the scholarly understanding of data governance by demonstrating that sovereignty is co-produced by both the state's legal architecture and the defensive commercial practices of market actors, thereby creating structural barriers to the global interoperability advocated by UN/CEFACT and ISO.

This state authority in case of data governance and sovereignty is consistent with Aaronson's (2021) characterisation of authoritarian digital mercantilism, where industrial and logistics data are treated as national resources. The reluctance of lessees to let the lessor see the utilisation data, if the leased container is a smart one, for instance, exemplifies how commercial secrecy and sovereignty converge to restrict data circulation. Theoretically, this suggests that sovereignty is enacted both vertically, through state regulation, and horizontally, through company-level protective strategies. This dual enactment deepens the framework's explanatory power by showing that data sovereignty is not a singular state project, but a constellation of practices shaped by both law and business mistrust.

The interviews highlight elasticity in sovereignty (Vatanparast, 2020; Mueller, 2020). The expressed willingness to share under customer request or international protocols points to conditional openings, which serve both commercial efficiency and geopolitical signalling. Such exceptions illustrate how the state stretches sovereignty to permit flows under controlled circumstances, reinforcing its authority while enabling participation in global trade facilitation. Yet the fact that these openings are case-by-case rather than systematic indicates that they do not yet constitute a robust framework for interoperability.

The contrast between rhetoric and practice is particularly significant. At the policy level, China positions its ambition to become a global of digitalisation and international standardisation, as evidenced in the Digital Silk Road. However, operational realities, as described by interviewees, remain restrictive and protectionist. This duality mirrors the role of LOGINK, China's logistics information platform, which is promoted as a beneficial for the global industry but simultaneously embeds mechanisms of surveillance and national oversight (USCC, 2022; Hummel et al., 2021). The implication is that infrastructures themselves become instruments of governance, aligning with Zuboff's (2019) contention that infrastructures are never neutral but inscribe political-economic rationalities. The significance of this duality is that China can project openness internationally while maintaining control domestically, allowing it to shape global digital norms on its own terms and reinforcing mistrust among international partners.

A critical contribution of these findings to theory is the identification of mistrust as an underexplored dimension of data sovereignty. Aaranson (2021), Vatanparast (2020) and Mueller (2020) showed that sovereignty can be perceived as a state-centred concept, but the empirical evidence shows how commercial actors operationalise sovereignty to defend bargaining positions, as lessees did by withholding utilisation data from the container owners, the lessors. This extends the theoretical debate by showing that sovereignty is co-produced: the state sets legal frameworks, but companies actively enact sovereignty through practices of restriction, secrecy, and selective sharing.

Internationally, the Chinese model diverges from Western rights-based and contractual autonomy traditions (Offor, 2020) and from multilateral approaches promoting interoperability (UN ECE, 2019). In contrast to the EU's GDPR, which emphasises individual rights and transparency, China's framework prioritises national security, industrial secrecy, and state control. This divergence raises practical barriers to interoperability, while Western frameworks seek to enable cross-border flows, China's sovereignty-based model seeks to contain and channel them under national oversight.

Comparison with international cases further illustrated this divergence. For example, Hapag-Lloyd and ZIM, both of which decided to fully digitise their container fleets, rely on IoT service providers such as Nexxiot, Orbcomm, and Hoopo, where could be shared with authorities or sold to shippers and integrated into supply chain platforms (Bruno,

2022; Uliel-Mirkin, 2024). These cases demonstrate a more open contractual model, where transparency and third-party validation are part of the value creation. By contrast, Chinese initiatives such as COSCO's IoT solution emphasise potential sovereignty and control, with interviewees noting reluctance to share data even among domestic actors. Furthermore, in Europe, GDPR-compliant systems are designed to guarantee user rights and cross-border portability, while Chinese frameworks such as DSL and PIPL impose restrictions on outbound flows unless state approval is obtained. The result is that China's approach diverges not only in principle but in practice, privileging protection and control over openness and interoperability. This divergence shows that China's sovereignty-centred approach could limit not only interoperability at home but also might risk isolating its smart container ecosystem internationally, undermining its ability to set global standards despite its scale.

In conclusion, the Chinese perspective on data governance demonstrates that data governance in global supply chains cannot be understood purely as a technical or contractual issue. Instead, the Chinese data governance approach must be seen as a politically and commercially embedded process in which sovereignty is asserted by both the state and businesses. Combined these insights show that China's approach to data ownership and sharing in the digitised supply chain is shaped by a sovereignty-first logic that overrides both contractual flexibility and currently shaping international practice of smart container data interoperability. While cases of Hapag-Lloyd and ZIM emphasise the value in the use cases related to the data sharing with the third party, the Chinese model demonstrates rather a retaining the visibility for the internal use, and selective access. The theoretical contribution of this analysis is to extend data governance theory by demonstrating that sovereignty is not only imposed from above but also enacted horizontally by corporates, producing a multilayered system of restrictions. The practical implication is that China's cautious and protectionist stance risks slowing global interoperability and fragmenting the governance of digital supply chains, since China is one of the mail players within the global transport and logistics industry. In answering *Research Question Two*, the study therefore shows that the Chinese perspective is not merely cautious but can be structurally incompatible with open, rights-based models of data exchange, closing Gap Two by demonstrating how sovereignty and mistrust concretely restrict data flows in practice and limit China's potential to influence global

standards. This duality closes Gap Two by showing how cybersecurity and sovereignty concerns translate into restricted openness at the operational level. Theoretically, the *Research Question Two* extends the framework by incorporating commercial mistrust as a dimension of sovereignty, and practically the question highlights the difficulty of achieving interoperability when data is framed as a sovereign and strategic asset.

6.4 Governmental Stimulation of the Chinese Smart Container

This section interprets the interviewees view on China's approach to container track-and-trace considering the theoretical frameworks and policy debates outlined in Chapter Two. The empirical findings demonstrated that while digitalisation is consistently framed as a strategic priority within both corporate and governmental discourse, implementation at the container level remains cautious, fragmented, and predominantly market driven. Interviewees described a dual narrative: at the strategic level, the state articulates a vision of technological leadership through *Made in China 2025* and the Belt and Road Initiative, underpinned by investment in upstream research, infrastructure, and participation in international standard setting bodies such as ISO TC 104; yet at the operational level, container owners and logistics companies base adoption decisions on commercial feasibility, customer demand, and return-on-investment logic. This disjuncture between declarative ambition and pragmatic execution illustrates a hybrid governance configuration in which strong state signalling coexists with company led rationalisation of costs and benefits.

The interviews further revealed that direct governmental stimulation of container-level IoT deployment is limited, confined largely to capped project-based grants and R&D tax waivers rather than structural subsidies. Technical barriers such as battery performance, communication reliability, and interoperability uncertainties exacerbate commercial caution, reinforcing dependence on market logic. As a result, digitalisation progresses selectively, concentrated in use cases where efficiency gains or customer requirements justify investment, while large scale fleet adoption remains rare. This pattern corresponded with the literature's portrayal of China's industrial modernisation as a process of guided market capitalism rather than centralised mobilisation, where the state

defines direction and legitimacy but delegates operational risk to enterprises (Kennedy, 2015; Zenglein & Holzmann, 2019; Naughton, 2021; Boullenois et al., 2025).

Conceptually, the findings aligned with accounts of China's regulatory evolution from rule taker to strategic participant, achieved not through blanket intervention but through institutional engagement and incremental norm shaping in global forum (Gao, 2011; Wang, 2018; Herold et al., 2021). They also suggested that policy narratives of digital sovereignty and global leadership translate unevenly into practice, producing a layered system in which national ambition drives discourse and standardisation activity, while the material rollout of smart containers remains determined by company-level economic calculus and fragmented coordination across agencies.

The analysis also considered the international legal setting that conditions the choice of instruments. Under the WTO Agreement on Subsidies and Countervailing Measures and GATT 1994 Article XVI (WTO, 1994), export-contingent and local-content-contingent subsidies are prohibited, while specific subsidies that cause adverse effects can be challenged, and members are expected to notify qualifying measures. In this context, horizontal R&D tax reliefs and guidance fund style financing, mentioned by the interviewees, are less exposed than overt, sector wide deployment subsidies, a distinction that aligns with interviewee reports of capped project grants and fiscal facilitation rather than direct programme funding for container IoT (WTO, 1995). An additional economic rationale was provided by recent economy innovation models. Bai et al. (2024) explained that in these dynamic general equilibrium frameworks, countries interact through trade while technology diffused internationally, and companies competed in research and development. Therefore, governments chose time-varying instruments, such as R&D support, standards and intellectual property policy, and, where feasible, trade policy to internalise cross-border knowledge spillovers, shape comparative advantage, and influence rivals' incentives (Bai et al., 2024). For this discussion, that meant China's reliance on horizontal R&D tax relief, guidance funds, and standards participation, rather than blanket, sector specific subsidies for container IoT, was consistent with the optimal policy logic identified in this literature and with the instrument mix reported by interviewees.

Finally, the discussion brought forward the institutional frictions identified in the findings. While China's presence in ISO aligns with an outward looking standardisation strategy, domestic coherence and global interoperability remain incomplete. Data governance and sovereignty requirements create compliance sensitivities for mobile assets, and hardware specifications for smart containers are still maturing, which together help explain cautious, customer-led adoption at the container level despite broader digital ambitions (Birkel & Hartmann, 2020; Raza et al., 2023; Zhang, 2024; Abbas et al., 2024).

The discussion must acknowledge the practical economics that shaped adoption choices. Interviewees highlighted unresolved battery and communications issues, client-driven demand, and the absence of credible, scalable return-on-investment evidence for dry containers as the principal barriers to mass deployment. These constraints, widely noted in the literature, meant that ports and terminal systems captured early investment while container-level roll-out remained contingent on customer requirements, demonstrable cost recovery, and regulatory certainty across jurisdictions (Raza et al., 2023). Together with domestic data sovereignty requirements and still maturing international specifications for smart containers, the near-term outlook was one of selective, limit fleet adoption rather than fleet wide saturation. The subchapters that follow develop this argument by examining how strategic signalling, technical frictions, standardisation dynamics, subsidy disciplines, sourcing choices, and the emergent pattern of selective state capitalism jointly structured China's pathway to container digitalisation, drawing implications for Research Questions One and *what is the Chinese approach towards using track-and-trace technology for shipping containers?* and *Research Question* Three *what is the potential influence of Chinese smart containers?* and addressing two gaps identified in the literature review Chapter Two, which highlighted the concerns of the absence of clarity on the extent to which Chinese governance and industrial practice align with international digitalisation frameworks and standards and the absence of empirical confirmation regarding the role of government stimulation, tax reductions, or strategic funding in supporting the adoption of container-level track-and-trace solutions.

6.4.1 Approach to Digitalisation: Strategic Vision versus Market Caution

The interviews indicated that container digitalisation could be framed as integral to national strategies such as *Made in China 2025* and the Belt and Road Initiative. This conclusion aligned with the literature that portrayed industrial modernisation as a state-led project combining technological upgrading with reputational signalling in international markets (Kennedy, 2015; Naughton, 2021; Boullenois et al., 2025; Zenglein & Holzmann, 2019). As interviewees described, the operative vision resembled a tiered architecture in which ports and terminal infrastructures first absorbed AI, IoT and cloud capabilities, generating visible efficiency gains and demonstration effects, with container-level devices envisaged as a subsequent layer. Their opinions are consistent with a governance model that prioritised high spillover platforms before moving into asset level applications, implying that state signalling and capability building had prepared the ground, but did not, by themselves, guarantee device level mobilisation.

At the point of adoption, companies nonetheless exercised a markedly commercial logic. Interviewees reported that container IoT deployment remained selective, customer-led and contingent on demonstrable value, with decisions for dry containers tied to specific client requirements, observed market response and explicit return-on-investment tests. This pattern mirrored the literature on fragmented and uneven diffusion in maritime logistics, in which company-level business models and cost structures, rather than national strategy alone, determined the speed and breadth of uptake (Raza et al., 2023). This study therefore suggests that, for the purposes of *Research Question One*, China's approach was best characterised as state signposting with company-led execution: strategic vision set direction, but adoption proceeded only where total cost of ownership, operational risk and client willingness to pay collectively justified investment. However, a certain disconnection between the Chinese companies' representatives and the governmental initiatives, identified during the engagement with the interviewees could signal a certain operational freedom and decision making strongly tightened with the pragmatic commercial considerations, such as high costs, low demand and therefore meanwhile insignificant return of investment.

The comparative reference to Germany further clarified the institutional conditions under which fleet-wide adoption could be expected. Interviewee 4 noted Germany's stated aim

of making all containers traceable, which treated track-and-trace as a fleet level commitment rather than a customer specific complement. The contrast implied that where regulatory and commercial arrangements socialised benefits and reduced coordination failures, comprehensive deployment became a collective objective; where benefits remained concentrated at the client level, adoption proceeded in a slow pace. In the Chinese case, the balance of incentives described by interviewees appeared to favour investment in ports and smart hubs, where gains were immediate and appropriable, while leaving container devices to follow only when customers were willing to pay or when costs fell sufficiently to meet internal benchmarks. The findings present a critical empirical correction to the "monolithic" interpretation of *Made in China 2025* often found in the sources (Lee, 2021b; State Council, 2015). While Wübbeke et al. (2016) and Boullenois et al. (2025) suggest that MIC25 provides a coherent foundation for technological self-sufficiency, the data reveals a "strategic-operational divide". China's approach is better characterised as "strategic conformism", adopting global narratives of Industry 4.0 leadership while delegating the actual operational risk and financial burden to individual enterprises (Gao, 2011; Wang, 2018). This extends developmental state theory (Johnson, 1999; Amsden, 2001) by illustrating that the state prioritises high-spillover infrastructure, such as smart ports, while allowing "peripheral" sectors like container-level IoT to remain reactive and market-driven. This helps explain why the narrative of leadership persisted alongside incremental roll-out.

These patterns of considerate and pragmatic smart container deployment planning also fitted the depiction in Chapter Two of China's regulatory evolution as one of selective rule adaptation within existing international regimes. Gao (2011) and Wang (2018) showed how China built influence by learning within institutions, shaping norms incrementally and allocating policy effort where external leverage and domestic capacity were greatest. Through this lens, the emphasis on standards participation and infrastructure-led modernisation signalled intent and built capability but did not imply unconditional subsidisation or rapid, asset level saturation. Therefore, it could be suggested that China's near-term influence would be more visible in standards, interfaces and data regimes than in device counts, with container-level diffusion advancing maritime trade corridor by corridor as commercial and technical conditions aligned.

In summary, the strategic operational divide observed in the interviews was not an anomaly, but a predictable outcome of the institutional and economic logics identified in the literature. State strategy and international engagement provided direction and legitimacy; companies acted as gatekeepers, releasing investment when use cases cleared internal thresholds. In addressing *Research Question One*, this meant that China's approach to container track-and-trace was ambitious in discourse yet cautious in execution, with mass deployment unlikely in the absence of stronger mechanisms to share costs and benefits or of clear evidence of recoverable returns. This conclusion sets the stage for the subsequent discussion of technical frictions, standardisation dynamics and the configuration of governmental support that further conditioned adoption.

6.4.2 Implementation Challenges: Cost, Battery, and Technical Viability

The interviewees indicated that unresolved technical and financial constraints had continued to impede large-scale deployment of smart devices on dry containers. Battery endurance remained a binding constraint, with annual replacement described as economically unrealistic at prevailing margins, and communications reliability, power supply, and compliance risks were repeatedly cited as additional barriers. These accounts aligned with the literature, which had shown that dry container applications lacked both the power budget and the established business case that underpinned reefer monitoring, where value propositions were clearer and device duty cycles more forgiving (Raza et al., 2023). Therefore, the following implication could be concluded as to technical durability and lifecycle cost functioned as primary gatekeepers of adoption, reinforcing a cautious, incremental trajectory in which companies deferred mass deployment until device performance and ownership costs converged on acceptable thresholds.

The interviewees also emphasised a strict return-on-investment calculus: adoption decisions were tied to specific customer demand, total cost of ownership, and the prospect of timely cost recovery. In this setting, lower cost identification tools such as QR codes and NFC had been used to cover basic track-and-trace use cases, even if they fell short of continuous telemetry. This pattern was consistent with studies highlighting that, without scalable energy solutions and economically maintainable devices, IoT rollouts struggled to demonstrate robust returns (Pagano et al., 2022; Gunasekaran et al., 2017). Therefore,

the resort to less capital-intensive substitutes suggested that Chinese companies potentially translated the state's digitalisation signal into a layered adoption path: platforms and hubs first, asset level digitalisation later, and interim identification solutions in between. The result for *Research Question One* was that market rationality, not policy narrative, determined the pace and form of container level instrumentation.

A further constraint arose from the compliance environment. Interviewees reported concerns over legal uncertainty across jurisdictions, which, coupled with domestic data sovereignty requirements, increased perceived risk around continuous sensing on mobile assets. As Chapter Two noted, China's data governance regime structured cross-border flows through localisation and approval mechanisms, and international interoperability remained incomplete. In practice, these frictions compounded technical risks and reduced the attractiveness of fleet wide investment, since deployment at scale would expose companies to heterogeneous regulatory obligations that were costly to monitor and enforce. The implication for *Research Question Three* was that, in the near term, the potential influence of Chinese smart containers would be channelled less through universal, device-level visibility and more through the consolidation of port and corridor systems where compliance and value could be more readily managed.

The interview data and the literature pointed to a coherent explanation for the observed prioritisation of ports and hubs over container devices. Where AI, IoT, and cloud platforms produced measurable process gains within bounded operational domains, investment proceeded; where asset-level deployments remained cost sensitive, power constrained, and compliance exposed, companies waited for stronger evidence of recoverable returns. This configuration was consistent with the theoretical framework developed in Chapter Two, in which a selective, capability-led model of state guidance coexisted with company-level return of investment discipline. In consequence, China's approach to container digitalisation was likely to remain incremental and corridor based until energy, communications, and compliance costs fell sufficiently to sustain a scalable business case for dry containers.

6.4.3 Standardisation: National Alignment and Global Aspirations

All interviewees stated that Chinese stakeholders had engaged actively in standards development across multiple levels. The participants described being involved in ISO/TC 104, contributions through professional associations, and collaboration with national bodies such as the National Standardisation Committee of China and the Ministry of Transport, with references also made to involvement in the International Maritime Organization. This multi-layered engagement aligned with the Literature Review Chapter Two's depiction of digitalisation as an institutionally constructed process through which actors sought legitimacy and influence, and with the literature that framed China's evolution from rule-taker to strategic participant in international governance by shaping norms from within established forums (Herold et al., 2021; Gao, 2011; Wang, 2018). Therefore, standards work functioned as an instrument of international presence and reputational signalling, consistent with the state-led modernisation narrative outlined in the previous section 6.4.2.

Some of the interviewees nevertheless reported persistent domestic fragmentation that had complicated the translation of international participation into interoperable practice. Accounts that "everyone pulled their own direction" suggested institutional silos and competing technological interests which made a unified position difficult to sustain across agencies and companies. Interview participants also pointed to compliance uncertainty arising from cross-border deployment of IoT devices, which compounded technical and commercial risks. These observations were consistent with the literature's emphasis on data sovereignty under China's Data Security Law and Personal Information Protection Law, and with the standardisation gap identified in maritime digitalisation, where national rules were highly codified, yet global harmonisation remained incomplete (Birkel & Hartmann, 2020; Raza et al., 2023; Zhang, 2024; Abbas et al., 2024). In practice, the misalignment between national data governance requirements and international expectations appeared to reduce companies' willingness to scale device-level sensing across multiple jurisdictions.

A further constraint lay on the hardware and interface side. Interviewees referred to the ongoing work in ISO/TC 104 SC 4 on a technical specification for smart container functionality and identification, which had not yet been published. The pending status of

this specification implied that minimum requirements for hardware interoperability, and performance verification were still evolving, which sustained a fragmented ecosystem in which manufacturers and operators faced heterogeneous certification and procurement pathways. This reinforced the layered view of IoT architectures presented in Chapter Two, that without stable, commonly adopted interfaces connecting sensing, networking, service, and application layers, end-to-end interoperability across-borders remained fragile, and limited fleet-based deployments were more likely than uniform, fleet-wide adoption (Birkel & Hartmann, 2020). However, it should not be expected that the release of the ISO smart container technical specification would unlock the slow deployment in China. While the literature suggested that China's standards posture had been ambitious and increasingly outward facing, the domestic coordination needed to convert ambition into interoperable outcomes remained partial. Standards become interoperable when implemented and harmonised with the national standardisation process. This procedure might take time and would not be the only challenge for the Chinese smart container adoption.

For *Research Question One*, this meant that China's approach to container digitalisation was institutionally active yet operationally cautious: companies drew legitimacy from participation in international forums while calibrating adoption to the realities of domestic data governance and the incompleteness of technical specifications. As to *Research Question Three*, the likely near-term influence lay more in agenda setting, shaping definitions, data models, and compliance expectations, than in immediate convergence on globally interoperable devices. Progress therefore depended on two linked conditions: improved domestic alignment across agencies and industry, and the timely publication and uptake of international specifications.

China's active participation in ISO/TC 104 confirms its strategic intent to transition from a "rule-taker" to a "rule-shaper" in global digital logistics (Gao, 2018; Wang, 2018; Lambrou et al., 2019). However, the data validates Herold et al.'s (2021) conceptualisation of digitalisation as a socially and institutionally constructed process that is often hindered by internal fragmentation. The observation that domestic stakeholders "pull in their own directions" as seen with Interviewee 6, who highlighted a "standardisation gap" that can prevent China from presenting a unified international position. This finding extends the sources by showing that the primary barrier to China's

global standardisation influence is not merely geopolitical tension but the lack of domestic coordination and the pending maturity of international specifications like ISO TS 25287.

6.4.4 Governmental Support: Fragmented and Indirect

The interviews indicated that governmental stimulation of container-level digitalisation had been fragmented and indirect. Respondents described modest, capped project grants and R&D tax deductions rather than sustained, all covering finance. In practice, companies bore the bulk of investment risk and proceeded only where customer demand and recoverable returns were credible. This helped to explain the recurrent gap between rhetorical endorsement of smart containers and the limited material support available to scale deployment.

This configuration was consistent with a financially mediated model of industrial policy documented in the literature, in which guidance funds, policy banks, and fiscal incentives channelled resources toward high-spillover priorities, while application-layer investments such as container telematics were left to market tests (Kennedy, 2015; Naughton, 2021; Boullenois et al., 2025; Zenglein & Holzmann, 2019). In effect, *Made in China 2025* and successor frameworks privileged platform building over device subsidisation, producing uneven sectoral reach and encouraging companies either to adopt lower-cost substitutes or to wait for clearer business cases. The pattern aligned with evidence that logistics digitalisation advanced first in domains where payoffs were immediate and appropriable, notably ports and hubs, rather than at the container level where lifecycle cost, power constraints, and compliance risks remained salient.

The observed instrument mix also made sense under multilateral subsidy disciplines. The WTO Agreement on Subsidies and Countervailing Measures prohibited subsidies contingent upon export performance or local content and rendered specific subsidies actionable where they caused adverse effects, while Members were expected to notify qualifying measures (WTO, 1995). GATT 1994 Article XVI reinforced notification and transparency regarding subsidies and their potential trade effects (WTO, 1994). Against this legal backdrop, horizontal R&D relief and project-based facilitation were less exposed than overt, sector wide deployment subsidies for a tradable, modular product such as container IoT. The preference for fiscal instruments reported by interviewees

therefore appeared strategically prudent, reconciling domestic upgrading goals with international legal constraints.

Throughout China's institutional strategy, this pattern was also compatible with the trajectory of rule-shaping from within identified in the literature review. As China built capacity and influence inside established regimes, the PRC adopted global norms for legitimacy while adapting instrument choice to domestic priorities and external scrutiny (Gao, 2011; Wang, 2018). Indirect support sustained the appearance of mobilisation and nurtured upstream capabilities without inviting the legal and political risks associated with visible, sector-specific deployment subsidies. In economic terms, the approach also cohered with recent open-economy innovation models, which showed that when international technology diffusion and rivalry were salient, welfare-maximising policy privileged innovation-side support and adjusted over time rather than relying on permanent downstream subsidisation (Bai et al., 2024). The findings confirm the depiction in the sources of "guided market capitalism" (Naughton, 2021), where the state provides symbolic signalling but requires companies to self-finance large-scale deployments. Contrary to the expectation of uniform state mobilisation derived from the trillions of RMB in tax deductions reported by Yu (2024) and the expansion of Government Guidance Funds noted by Luong et al. (2021), the container industry has received negligible direct funding. This research extends developmental state theory by demonstrating that in the context of IoT, the state adopts a "financially mediated" variant of industrial policy that privileges platform-building (e.g. LOGINK) over asset-level instrumentation.

For *Research Question One*, the implication was that state signposting coexisted with company-led execution. Policy set the horizon and funded enabling capabilities, but adoption at the container level proceeded only where return-on-investment thresholds and client willingness to pay were met. For *Research Question Three*, the expected near-term influence laid less in fleet-wide saturation than in standards entrepreneurship, capability formation, and corridor-based diffusion, with legal constraints and market calculus jointly discouraging blanket deployment subsidies. In sum, governmental support in this domain appeared selective by design, compatible with WTO and GATT obligations, aligned with China's institutional playbook, and consistent with a policy logic that prioritised upstream innovation over downstream mass subsidisation.

6.4.5 Technology Origin

The interviewees suggested that companies professed openness to international vendors and evaluated solutions primarily on functionality, reliability, and cost. In practice, however, procurement decisions frequently favoured domestic manufacturing. Respondents attributed this preference to supplier proximity, closer quality oversight, ease of coordination, and the perceived fit with local regulatory and data governance requirements. In the prism of the literature review, presented in Chapter Two, this combination of discursive openness and practical localisation was consistent with accounts of pragmatic globalism in Chinese logistics and with a developmental state logic that nurtured indigenous capability where strategic assets and data were implicated (Lambrou et al., 2019; Naughton, 2021; Voorspuij & Becha, 2021).

Several mechanisms appeared to explain the divergence between stated openness and domestically anchored practice. Firstly, proximity reduced transaction costs in compliant production, factory acceptance testing, and after sales support, which mattered for devices that required iterative integration with carrier systems. Secondly, domestic manufacturers were better positioned to align maintenance processes with evolving local requirements, shortening iteration cycles and lowering operational risk. Thirdly, where companies had already invested in local ecosystems for connectivity, like mobile telecommunication of Huawei and ZTE container manufacturing for immediate deployment of the IoT devices onto new built containers, like CIMC, marginal additions from domestic suppliers could minimise integration frictions. Together, these drivers generated a path dependence that reinforced domestic sourcing even when foreign alternatives were technically acceptable.

Institutional pressures associated with data governance provided a further rationale. As discussed in Section 2.4.1.2 and Section 3.4, China's data regulatory architecture prioritised localisation, auditability, and state access, features that heightened scrutiny of continuous sensing on mobile assets. Under such conditions, domestically produced hardware was perceived as a lower risk route to organisational legitimacy, because vendor practices, update cycles, and compliance documentation could be aligned more readily with national expectations (Scott, 2014; Zhang, 2024). The result was not a categorical exclusion of foreign technology but a probabilistic tilt toward local suppliers when procurement involved sensitive data flows, device telemetry, or security relevant

interfaces. This tilt was amplified by the need to demonstrate compliance to multiple domestic stakeholders, such as customers, regulators, and internal assessment committees, under uncertainty about cross-border enforcement.

The pattern also cohered with China's incremental strategy of rule shaping from within international regimes. Active participation in ISO/TC 104 and related forums signalled outward engagement, but domestic standards and data governance priorities continued to anchor procurement choices at home. In theoretical terms, the coexistence of international presence and domestic preference reflected selective state capitalism: the state invested in platforms and standards to build voice internationally, while companies, operating under domestic regulatory constraints and RoI discipline, sourced locally where transaction costs and compliance risk were lower (Gao, 2011; Naughton, 2021; Wang, 2018). This configuration implied that interoperability would improve where international and national specifications converged, but that, absent such convergence, deployment would remain corridor based and ecosystem specific.

This pragmatic preference for domestically anchored procurement provides critical empirical weight to the literature concerning 'technological sovereignty' and 'selective openness' within the *Made in China 2025* framework (Boullenois et al., 2025; Wübbeke et al., 2016). While the sources suggest that China seeks to reduce foreign dependency through state-mandated substitution (Guo & Jin, 2018), the findings of this study extend this narrative by identifying a more nuanced 'institutionalised selectivity'. Procurement decisions are not merely driven by protectionist mandates but by the need for 'governance alignment'. Domestic hardware is perceived as a lower-risk route to organisational legitimacy because it facilitates compliance with the Data Security Law (2021) and the Personal Information Protection Law (2021), which treat industrial data as a sovereign asset (Zhang, 2024). This finding also contributes to the sources by refining Scott's (2014) institutional theory, demonstrating that in highly regulated digital environments, 'coercive pressures' for national security compliance effectively override the 'mimetic pressures' of global technological standardisation.

For *Research Question One*, the implication was that China's approach to container track-and-trace remained market led but nationally embedded: companies evaluated vendors globally yet defaulted to domestic suppliers when integration, governance alignment, and

lifecycle control dominated the calculus. For *Research Question Three*, the likely influence was asymmetrical. China's international participation positioned itself to influence interfaces and data models, but domestically anchored procurement created compatibility clusters that might limit immediate, friction-free interoperability with foreign fleets. Over time, the degree to which international standards and China's data governance regime converged would determine whether the present pattern evolved into broader, cross-jurisdictional compatibility or settled into parallel, partially interoperable systems.

6.4.6 Identified Patterns in Data Governance and Sovereignty

Through the lenses set out in Chapter Three, Theoretical Framework, the findings cohered with a developmental state interpretation in which the state articulated technological horizons and built enabling platforms, while refraining from blanket device subsidisation. The emphasis on ports, terminals and data infrastructures ahead of container level digitalisation was consistent with a selective mobilisation of resources towards high spillover layers of the stack, leaving downstream adoption to company-level cost-benefit tests (Naughton, 2021; Zenglein & Holzmann, 2019). In this sense, the observed pattern did not contradict developmental state theory; rather, the pattern reflected its contemporary, financially mediated variant in China, where guidance funds, fiscal incentives and standards work substituted for broad, programme-level subsidies.

Strategic industrial policy further illuminated this configuration. The instrument mix reported by interviewees, such R&D tax relief, project-based support and standards participation, matched a policy logic that prioritised capability building over permanent deployment subsidies and that adjusted as technologies and markets evolved (Kennedy, 2015; Boullenois et al., 2025). Recent economy innovation models reinforced this conclusion by showing that, under international diffusion and rivalry, welfare maximising policy tilted towards innovation side support rather than persistent product level subsidisation, with the optimal mix evolving over time (Bai et al., 2024). From the findings in Section 5.4.1 identifying the technology deployment based on client demand, as stated, for example by the Interviewee 3, the selective, RoI screened progression from ports and terminals digitalisation to limited container deployments therefore appeared as

an expected outcome of strategic industrial policy under external constraints and budget discipline.

The data governance and sovereignty framework offered a complementary explanation for domestically anchored procurement and cautious cross-border scaling. China's data regime, centred on the Data Security Law and the Personal Information Protection Law, framed industrial data as a sovereign resource and imposed localisation, audit and access requirements that were difficult to reconcile seamlessly with heterogeneous international expectations (Zhang, 2024). In practice, these provisions elevated compliance risk for mobile sensing on containers, making domestically produced hardware and locally integrated platforms a lower-risk path to organisational legitimacy. This logic amplified technical and commercial frictions already present in dry container use cases and helped to explain why companies prioritised ports and terminal systems, bounded operational domains with clearer governance, over fleet wide instrumentations (Raza et al., 2023).

Institutional theory tied these strands together by clarifying the role of legitimacy seeking and decoupling. Active participation in ISO/TC 104 and related fora signalled alignment with global scripts and supported China's gradual move from rule-taker to selective rule-maker through incremental norm shaping (Gao, 2011; Wang, 2018; Herold et al., 2021). At the same time, interview reports of domestic dissonance and siloed interests indicated partial decoupling between formal commitments and operational practice, a pattern consistent with coercive, normative and mimetic pressures producing outward conformity while internal coordination lagged (Scott, 2014). The pending status of the ISO Technical Specification 25287 on smart container functionality and identification, together with the incomplete harmonisation between China's domestic data governance rules and international data exchange frameworks, sustained this ambiguity and further constrained both the speed and breadth of adoption. In the absence of a finalised specification, Chinese organisations faced uncertainty regarding the technical, functional and compliance requirements that future international standards would impose, which could reduce the incentive to commit to large scale deployment and limited the development of fully interoperable solutions.

In combination, these frameworks explained why the empirical pattern was strategically ambitious and institutionally engaged, yet operationally fragmented and fiscally selective.

Developmental state selectivity and strategic industrial policy accounted for the emphasis on upstream capabilities and the reliance on indirect instruments; the data sovereignty lens clarified domestically anchored sourcing and limit fleet based smart container scaling; and institutional theory explained how international engagement could coexist with uneven domestic coordination. Absent clearer returns, mature technical specifications and more predictable cross-border data arrangements, container-level digitalisation was therefore likely to continue along a selective, RoI-disciplined trajectory rather than a unified national mobilisation.

This configuration substantiates the literature's depiction of 'guided market capitalism', where the state provides strategic signalling but requires enterprises to absorb the operational risks of innovation (Naughton, 2021). The findings extend this conceptualisation by identifying a 'strategic-operational divide' in the smart container sector: while the state projects an image of digital leadership along the Maritime Silk Road (Al Shaher et al., 2023; Hlongwa, 2020), actual implementation is deferred by market-driven caution and technical frictions. This research contributes to the existing sources by characterising China's influence as 'strategic conformism' (Gao, 2011; Wang, 2018). Rather than achieving global dominance through a rapid, state-funded saturation of the fleet, China exerts influence through 'standards entrepreneurship' and the shaping of international data models within ISO/TC 104. This study concludes that the potential influence of Chinese smart containers is therefore likely to be 'financially mediated' and 'corridor-based', diverging from the monolithic mobilisation often predicted in early analyses of *Made in China 2025* (Lee, 2021b).

6.4.7 Summary of Discussion on Governmental Stimulation of the Chinese Smart Container

The discussion showed that China's approach to container digitalisation had combined strong strategic signalling with selective, market mediated execution. National strategies, such as *Made in China 2025* and the Belt and Road Initiative framed digitalisation as a pillar of industrial upgrading, and Chinese actors participated actively in international standard-setting, consistent with a move from rule-taker to selective rule-maker within existing regimes (Gao, 2011; Wang, 2018; Herold et al., 2021). At the point of adoption, however, companies proceeded cautiously. Battery endurance, communications

reliability, integration effort, and compliance risk raised lifecycle costs, while credible, scalable returns remained uncertain for dry containers. This configuration explained the prioritisation of ports and hubs over container fleet-wide IoT device deployment.

Furthermore, this identified prioritisation of the infrastructure digitalisation over container level digitalisation provides a critical empirical correction to the "monolithic" interpretation of *Made in China 2025* often found in the sources (Lee, 2021b; State Council, 2015). While researchers such as Wübbeke et al. (2016) and Boullenois et al. (2025) suggest that MIC25 provides a coherent foundation for technological self-sufficiency, the findings of this study expand the literature by revealing a pronounced "strategic-operational divide". By demonstrating that the state prioritises infrastructure-building, such as smart ports, over the instrumentation of individual shipping assets, the research refines the characterisation of China's industrial policy as "strategic conformism", where the state projects an image of digital leadership while delegating the actual operational risk and financial burden to individual enterprises (Gao, 2011; Wang, 2018). Governmental stimulation appeared fragmented and indirect. Interviewees described capped project grants and horizontal R&D tax relief rather than sustained, programme-level finance for container telematics. This instrument mix was consistent with a contemporary, financially mediated variant of the developmental state and with strategic industrial policy that privileged capability building in high-spillover layers of the technology stack while leaving device decisions to company level cost-benefit calculations (Kennedy, 2015; Naughton, 2021; Boullenois et al., 2025; Zenglein & Holzmann, 2019). The governmental stimulation instrument also aligned with multilateral constraints: under the WTO Agreement on Subsidies and Countervailing Measures and GATT 1994 Article XVI, export or local content contingent subsidies were prohibited, and specific, trade-distorting measures were actionable, while broadly available R&D support was less exposed to challenge (WTO, 1994; WTO 1995). Alongside economy innovation models that favoured innovation-side support over permanent downstream subsidisation in the presence of international diffusion and competition, China's reliance on fiscal R&D instruments and guidance fund finance appeared coherent with optimal policy logic (Bai et al., 2024). The findings indirectly support the refinement of the depiction in the sources of "guided market capitalism" (Naughton, 2021). By confirming that container-level IoT has received negligible direct

funding, the study reduces the assumption of uniform state mobilisation derived from the trillions of RMB in tax deductions reported by Yu (2024) and the expansion of Government Guidance Funds noted by Luong et al. (2021). Instead, the theory has been developed to show that in the context of smart logistics, the state adopts a "financially mediated" variant of industrial policy that privileges symbolic signalling and fiscal facilitation over systematic asset-level subsidisation.

Standardisation and data governance both enabled and constrained progress in Chinese maritime sector. However, institutional engagement enabled progress by allowing Chinese stakeholders to seek influence through ISO/TC 104 and related forums, positioning the state to transition from a rule-taker to a rule-maker in global digital logistics as seen with Interviewee 1, Interviewee 4 and Interviewee 5. This active participation in international technical committees was viewed as a strategic exercise in reputation building and a means to foster industry growth through the integration of advanced digital and artificial intelligence technologies, as stated by Interviewee 4 and Interviewee 5.

As for domestic fragmentation there is a significant containment as to this momentum, as internal institutional silos and competing technological interests led to a scenario where domestic stakeholders frequently “pulled in their own directions” rather than forming a unified national position (Interviewee 6, Line 374-377). Furthermore, the incomplete harmonisation of national and international rules limited the translation of participation into interoperable practice, as the installation of smart devices often resulted in compliance uncertainties and regulatory conflicts across different jurisdictions (Interviewee 3, Line 104-117). This lack of a universally harmonised framework, particularly while the ISO TS 25287 technical specification remains pending, has fostered a watching and waiting stance among shipping companies (Interviewee 3, Line 113-117).

From the perspective of data governance, this concept acts as a further dual force, as contractual logic suggests data belongs to the end-user (Interviewee 3, Line 240-242), persistent commercial mistrust and concerns regarding trade secrets frequently overrode the strategic rhetoric of openness and restricted the circulation of data (Interviewee 1, Line 152-156; Interviewee 8, Line 74-75). This pattern confirms the observations in the literature that adoption in maritime logistics remains fragmented and uneven, shaped

more by individual business models and the need to align with a statist sovereignty framework than by a singular national strategy (Raza et al., 2023; Zhang, 2024).

The uncertainty related to the smart container shaping standards left hardware expectations unsettled, while China's Data Security Law and Personal Information Protection Law heightened sensitivity around cross-border data flows. In this environment, procurement showed a pragmatic tilt toward domestic manufacturers owing to supplier proximity, quality oversight, and regulatory alignment, even as companies professed openness to international vendors. The outcome was a customers' demand driven pattern of diffusion rather than immediate, fleet-wide saturation.

This discussion directly addressed the two gaps specified in Chapter Two. Firstly, the outcome of the study indicated that the extent to which Chinese governance and industrial practice aligned with international digitalisation frameworks and standards, the evidence demonstrated partial but incomplete alignment. Chinese stakeholders participated actively in ISO/TC 104 and related organisation, signalling engagement with international rulemaking, yet domestic coordination remained fragmented and data governance requirements constrained seamless cross-border interoperability. In practice, companies adopted a pragmatic approach to deployment and tended to favour domestic sourcing to manage compliance and integration risks, which clarified that alignment with international frameworks existed institutionally but was only partially realised operationally.

Secondly, the study focused on the role of government stimulation, tax reductions, or strategic funding in supporting container-level track-and-trace adoption, the interviews provided empirical confirmation that support had been selective and indirect. Companies consequently self-financed and paced adoption according to return-on-investment thresholds, customer willingness to pay, and technical viability. This evidence established that governmental instruments had facilitated upstream capability building but had not furnished decisive, sector-wide incentives for mass instrumentation of dry containers. Combined these findings closed the two gaps by specifying the nature and limits of China's international alignment and by documenting, with empirical detail, the circumscribed role of subsidies, tax measures, and strategic funding in container digitalisation.

As to *Research Question One*, the Chinese approach to container track-and-trace was best understood as state signposting with companies-led execution: the state articulated direction and invested in enabling platforms, while enterprises paced adoption according to customer demand, total cost of ownership, and compliance assurance. Addressing *Research Question Three*, China's near-term influence laid more in standards entrepreneurship, capability formation, and the shaping of data and interface regimes than in rapid quantitative expansion of smart containers. Therefore, the developmental state, strategic industrial policy, data governance and sovereignty, and institutional theory lenses offered a coherent explanation of the hybrid pattern observed: strategically ambitious and institutionally engaged, yet operationally fragmented and fiscally selective. Without clearer evidence of recoverable returns, matured technical specifications, and more predictable cross-border data arrangements, large scale IoT device deployment was likely to remain incremental.

6.5 Summary and Conclusion of the Discussion

This chapter interpreted the empirical findings in Chapter Five through the theoretical and conceptual frameworks introduced in Chapters Two and Three, providing a comprehensive understanding of China's approach to container digitalisation. The discussion demonstrated that the Chinese model is characterised by a *layered hybridity*, a blended configuration of state ambition, market pragmatism, and institutional selectivity. Across all three research questions, a consistent pattern emerged: strategic endorsement and active international participation coexisted with commercially driven implementation, fragmented coordination, and cautious diffusion at the operational level.

In relation to *Research Question One*, which examined the Chinese approach towards using track-and-trace technology for shipping containers, the analysis revealed a system guided by strong policy signalling but executed according to market logic. The findings showed that while digitalisation is rhetorically positioned as a strategic priority under frameworks such as *Made in China 2025* and the Belt and Road Initiative, adoption decisions at the corporate level remained governed by cost, technological readiness, and return on investment considerations. The technology-organisation-environment (TOE) framework (Tornatzky & Fleischer, 1990) was expanded to include value capture and incentive alignment as essential determinants, as technological readiness alone did not

guarantee adoption across different ownership structures. By synthesising the findings in Chapter Five with the literature in Chapter Two, this research extends the concept of the "digital divide" identified by Raza et al. (2023) and Manners-Bell (2023). The data demonstrate that this divide is not merely technological but is rooted in asymmetrical incentive alignment; whereas operators seek the "digital twin" visibility advocated by Ivanov (2021), leasing companies, who control approximately 50% of the fleet, exhibit profound reluctance because they lack fundamental interests in the asset's data. The developmental state perspective helped explain the duality of state-led direction and company-led execution; by this the developmental state theory was refined into a financially mediated variant, confronting the assumption of uniform, state-funded mobilisation by showing that while the state is effective at setting agendas, it remains less effective at driving asset-level deployment when commercial incentives remain misaligned**.** Therefore, China's approach can be described as ambitious in vision but cautious in realisation, resulting in incremental and limited fleet deployment rather than full fleet mobilisation.

In response to *Research Question Two*, which investigated the Chinese perspective on data ownership and sharing in the digitised supply chain, the discussion established that China's data governance model operated within a sovereignty-first logic. Contractual practices at the corporate level were nested within state-centred legal frameworks such as the Data Security Law and the Personal Information Protection Law. The findings extend the theory of "elastic sovereignty" (Vatanparast, 2020; Mueller, 2020) by identifying commercial mistrust as a horizontal enactment of sovereignty. While existing literature by Zhang (2024) and Abbas et al. (2024) focused on the vertical authority of the state, this research demonstrates that sovereignty is co-produced: the state sets legal frameworks, but companies actively enact sovereignty through restrictive practices and selective sharing to defend competitive bargaining positions. This horizontal enactment creates structural barriers to the global interoperability sought by international bodies like UN/CEFACT and ISO. This configuration produced a dual system where companies formally controlled their operational data but remained bound by national constraints on sharing and cross-border transfer. The Data Governance and Sovereignty Framework was expanded through the identification of 'horizontal sovereignty', where commercial mistrust among market actors' functions as an operative dimension of control alongside

vertical state authority. This extension demonstrates that sovereignty is co-produced: the state establishes the legal architecture (DSL, PIPL), but companies actively enact sovereignty through defensive practices of restriction and selective sharing to protect bargaining positions. Sovereignty, therefore, functioned both vertically, through state regulation, and horizontally, through company-level secrecy and selective sharing. The concept of "elastic sovereignty" captured this flexibility, allowing controlled openness under specific circumstances while maintaining overall state authority. Empirically, this results in a cautious, protectionist stance that prioritised control over interoperability, in contrast to Western market-oriented models. Theoretically, this finding extended the Data Governance and Sovereignty Framework by showing that commercial mistrust was an operative dimension of sovereignty, enacted by corporates as much as imposed by the state.

Addressing *Research Question Three*, which examined the potential influence of Chinese smart containers, the discussion concluded that China's priority was likely to manifest more strongly through standard setting and capability building than through rapid quantitative expansion of digitalised containers. Governmental support was shown to be selective and indirect, limited to capped project-based grants and research and development tax relief rather than large-scale subsidies. Institutional Theory was refined to account for the partial decoupling observed between China's active participation in global standardisation (e.g., ISO/TC 104) and its fragmented domestic coordination. The findings refined Scott's (2014) pillars of institutional influence by showing that coercive pressures for national security compliance effectively override the pressures of global technological standards, leading to strategic conformism, where China adopts global norms for legitimacy while maintaining domestic discretion in practice. This outcome reflected both China's financially mediated developmental state model and compliance with multilateral subsidy disciplined under the WTO and GATT frameworks. Consequently, digitalisation advanced most rapidly in ports, hubs, and high value corridors, where efficiency gains are tangible and risks controllable, while limit container fleet level deployment remained selective and customer driven. The near-term influence of Chinese smart containers therefore was expressed in the institutional sphere, through the shaping of standards, interfaces, and data regimes, rather than in immediate fleet wide transformation. However, the study provides a critical assessment of China's "rule-

shaping" ambitions. While the sources confirm China's intent to move from a rule-taker to a rule-shaper in ISO/TC 104 (Gao, 2018; Wang, 2018), the findings reveal a significant "standardisation gap" caused by internal fragmentation. The observation that domestic stakeholders "pull in their own directions" validates Herold et al.'s (2021) view of digitalisation as a socially and institutionally contested process, highlighting that internal coordination deficits remain as much a barrier to global influence as external geopolitical tensions**.**

Therefore, the findings and their interpretation depicted a digitalisation pathway that was strategically ambitious, institutionally engaged, and globally visible, yet operationally fragmented and fiscally restrained. The developmental state and strategic industrial policy perspectives explained the selective nature of governmental involvement; the data governance framework clarified the sovereignty-based limitations on data flows and international interoperability; and institutional theory elucidated how China sought legitimacy through participation in global forums while maintaining domestic discretion. The resulting configuration exemplified a contemporary form of guided market capitalism, in which policy direction and industrial transformation evolved through negotiation rather than command.

In conclusion, the discussion chapter showed that China's approach to smart container was neither purely state-driven nor purely market based, but a synthesis of both. The study has combined long-term strategic signalling with pragmatic, company level implementation and selective state facilitation. By this the developmental state theory was refined to explain why progress was visible in standards, infrastructure, and global engagement, but less so in widespread device deployment and data sharing. This hybrid model explained why progress was visible in standards, infrastructure, and global engagement, but less so in widespread device deployment and data sharing. The outcome has also highlighted the tension between China's aspiration to shape global norms and its adherence to sovereignty-preserving domestic governance. Collectively, these insights closed the research gaps identified in Chapter Two by providing empirical and theoretical evidence on adoption dynamics, data governance practices, and the role of governmental stimulation in the Chinese smart container ecosystem. By refining the developmental state model, institutional theory and expanding both the TOE and data sovereignty frameworks, this research provides a more nuanced theoretical account of how

digitalisation unfolds in a globally integrated yet politically contested maritime environment.

7 Conclusion of the Chinese Smart Container Study

7.1 Overview of the Study Conclusions

The conclusion of this doctoral study serves both to close the circle of inquiry and to open new avenues for reflection and research. This Chapter synthesises the insights generated through the critical literature review, the conceptual frameworks developed in Chapter Three and the qualitative evidence examined in Chapters Five and Six, presenting an integrated account of what the study reveals about container digitalisation in China and its implications for global supply chain governance.

This Chapter revisits the research aim and objectives, demonstrating how these were achieved through an integrated methodological approach combining thematic analysis, bilingual coding and contextual interpretation. This conclusion part then evaluates the quality of the study using the criteria proposed by Guba and Lincoln (1989), considers its limitations, and outlines future research by provide recommendations. Finally, the Chapter discusses the study's academic and managerial contributions, before concluding with a synthesis of its significance for understanding global digitalisation in an era of geopolitical and technological transformation.

7.2 Addressing the Research Aim

The overarching aim of this study was to investigate China's approach to container digitalisation, focusing particularly on track-and-trace technology, data governance, and the implications for global logistics. This aim was pursued through a multi-layered inquiry that combined theoretical framing and empirical evidence. On the theoretical level, the research drew upon four frameworks: developmental state theory, the technology-organisation-environment (TOE) framework, data governance and

sovereignty perspectives, and institutional theory. Together, these frameworks enabled a structured yet flexible interpretation of China's evolving industrial strategy and the interplay between political ambition, technological capability, and market logic.

From the empirical perspective, the study employed semi-structured interviews with Chinese stakeholders, conducted in Chinese and English, to capture how national strategy was translated into operational decisions. The analysis revealed that China's digitalisation of smart containers was characterised by layered hybridity, a term developed in this study to describe the co-existence of state ambition, company-level pragmatism, sovereignty-driven governance, and institutional contestation.

The research aim was operationalised through four specific objectives, all of which were successfully achieved. *Objective One*, which focus on identifying through a critical review of the literature as to how track-and-trace technology has been conceptualised and adopted within Chinese container maritime transportation, was addressed through the systematic examination of existing academic and industry research presented in Chapter Two. This analysis clarified the technological foundations of smart container systems, positioned China's digitalisation strategy within the broader Industry 4.0 context, and identified the conceptual and empirical gaps that justified the present study. As for *Objective Two*, aiming to analyse empirically the Chinese approach to track-and-trace technology for shipping containers, this was achieved by demonstrating that while strategic ambition is pronounced, adoption remains selective, shaped by ownership structures, cost sensitivities, and uneven technological readiness. In addressing *Objective Three*, focused on evaluating the Chinese perspective on data ownership and sharing in the digitised supply chain, this research goal was reached by identifying a hybrid data governance regime that blends sovereignty with contractual pragmatism, underpinned by mistrust among companies and a preference for bilateral rather than systemic sharing. *Objective Four*, which was aimed at interpreting the empirical findings within the broader context of China's industrial policy objectives, was achieved by demonstrating how container digitalisation is embedded within wider national strategies such as *Made in China 2025* and related digital infrastructure initiatives, revealing how technological deployment, regulatory frameworks and industrial ambition interact within China's distinctive political economy. Collectively, these objectives realised the research aim and uncovered additional insights, including the recognition of pragmatism as a distinctive

Chinese mode of engagement and the identification of company-to-company mistrust as a critical obstacle to interoperability and data exchange.

Beyond meeting each objective individually, the study also demonstrated how the four theoretical frameworks, developmental state theory, the technology-organisation-environment (TOE) framework, data governance and sovereignty perspectives, and institutional theory, operate most powerfully when viewed in combination. Each framework illuminated distinct dimensions of Chinese container digitalisation, yet their integration revealed the phenomenon's inherent ambivalence and hybridity.

The developmental state framework explained the paradox of ambition without mobilisation, showing that while the state articulates a clear strategic direction through *Made in China 2025* and the BRI, its material support is symbolic and project based. The TOE framework identified ownership asymmetries and technological bottlenecks as key firm-level constraints, demonstrating that readiness alone does not ensure adoption. The data-governance lens clarified how sovereignty, contractual pragmatism, and mistrust coexisted, producing a hybrid model of restricted data sharing. Institutional theory exposed the dual logic of global legitimacy and domestic reliance, explaining why China's standardisation system is internally contested.

Integrating these perspectives produced a holistic understanding: China's smart container strategy was shaped not by any single determinant but by the intersection of multiple, sometimes conflicting forces. Across the frameworks, recurring dualities, ambition versus constraint, readiness versus bottlenecks, contractual obligations versus sovereignty, and openness versus reliance, emerge as defining features of this layered hybridity. These dualities revealed that ambivalence was not accidental but structural, rooted in China's political economy and the global logistics environment.

7.3 Academic Contribution and Theoretical Advancement

This study made a substantive contribution to academic understanding of digital transformation in China's maritime logistics by addressing the four research gaps identified in Chapter Two and advancing theoretical insight through an integrative framework referred to as layered hybridity. Empirically grounded in China's container

digitalisation, the research demonstrated how technological adoption, data governance, and institutional participation were embedded within a complex political economy that combined state ambition with commercial pragmatism. The study extended and refined several established theoretical frameworks, including developmental state theory, the technology-organisation-environment model, data governance theory, and institutional theory, by situating them within a single analytical construct that explained fragmented, asymmetric, and contested digitalisation processes. This argument builds directly on the patterns identified in Chapter Five, particularly Sections 5.2 to 5.5, which demonstrated empirically that container digitalisation unfolded through competing political, organisational, and commercial logics rather than through linear technological advancement.

Addressing the first research gap concerning market penetration and supply chain influence, the study showed that adoption of smart container technologies in China was strategically endorsed but operationally fragmented, shaped by ownership asymmetries between operators and lessors and by uneven incentive alignment. This conclusion extended the technology-organisation-environment framework beyond its conventional focus on technological readiness and environmental pressure by embedding adoption decisions within institutional and political contexts. The findings in Section 5.2 demonstrated that interviewees consistently emphasised ownership structure and cost allocation as the primary determinants of adoption, supporting and extending earlier observations in the literature (e.g. Hummel et al., 2021; Scott, 2020) that asset ownership influences digital capability development. By demonstrating that readiness alone was insufficient without ownership-based value capture, the research contributed to a more dynamic and relational understanding of technology adoption in asset intensive industries, where power asymmetries determined both diffusion and return on investment.

In relation to the second gap concerning cybersecurity and data sovereignty, the study advanced data governance theory by revealing that sovereignty was not only exercised through regulation but also enacted in commercial practice. Empirical evidence of contractual mistrust and selective sharing among Chinese logistics companies showed that data governance is co-produced by the state and by industry actors, where legal sovereignty intersected with corporate secrecy to limit openness. This finding is consistent with Chinese data governance research referenced in Chapter Two, particularly

the work of Gao (2021) and Cortes-Murcia (2022) and is substantiated by the interview patterns described in Section 5.3, where participants repeatedly expressed caution regarding data transfer to external parties. This hybrid logic of control refined existing theory by identifying mistrust as a structuring variable in data politics, demonstrating that political culture, national legislation, and business pragmatism jointly shape the boundaries of digital trust. This finding shifted the discussion from sovereignty as a vertical expression of state power to its horizontal enactment within market relationships.

The third research gap concerning alignment with international practices was addressed through the analysis of selective and conditional participation in global standardisation. Although China engaged actively in international bodies such as ISO TC 104, domestic coordination remained fragmented, and implementation often followed a pattern of pragmatic globalism, characterised by rhetorical openness combined with domestic reliance. Section 5.4 of the findings provided detailed evidence of this dynamic, with interviewees describing inconsistent internal coordination and strategic participation in global forums that aligned with China's political signalling rather than with full technical convergence. This confirms the arguments of researchers such as Kennedy (2017) and Zenglein and Holzmann (2019), who describe China's international standardisation posture as selective, and interest driven. This finding challenged linear models of globalisation that assumed convergence towards uniform standards and showed that institutional legitimacy could be achieved through fragmented participation and strategic signalling rather than through full harmonisation. The study thereby extended institutional theory by demonstrating that coherence was not a prerequisite for influence, as states and companies could project international credibility while maintaining differentiated domestic practice.

The fourth research gap, which concerned governmental stimulation and industrial policy, was addressed through an empirical and theoretical refinement of developmental state theory. Contrary to the assumption of direct fiscal mobilisation, the study demonstrated that China's approach to container digitalisation relied on symbolic and indirect instruments such as capped project grants, research and development tax relief, and participation in standards, rather than on sector-wide subsidies or centralised investment. This finding is anchored in Section 5.4, where interviewees described a system of targeted, symbolic, and legitimacy-oriented government involvement rather than the

direct support described in classical developmental state literature (Johnson, 1982; Amsden, 1989). The outcome also supports contemporary interpretations of China's industrial governance (Naughton, 2021; Zenglein & Holzmann, 2019), which emphasise guidance mechanisms over broad subsidy allocation. This pattern illustrated a contemporary, financially mediated variant of the developmental state that operated through legitimacy-based rather than subsidy-based intervention. The research reconceptualised state influence in digital transformation not as resource mobilisation but as strategic guidance, normative framing, and selective support. By demonstrating that state ambition provided direction while companies implement projects according to commercial logic, the study identified a model of strategic signalling combined with market execution, a configuration that explained both the ambition and restraint evident in China's digitalisation trajectory.

The principal theoretical contribution of the study was the formulation of layered hybridity as a conceptual framework for analysing digitalisation in politically complex environments. This framework integrated four interdependent dimensions, namely state ambition articulated through industrial strategy and international engagement, company pragmatism driven by container ownership asymmetry, i.e. owners lessors and owners operators, and return on investment, sovereignty embedded in data governance practices that combined regulation with commercial secrecy, and institutional contestation arising from the interaction of global norms, domestic priorities, and market imperatives. Chapter Six (Section 6.5) demonstrated how these layers intersected empirically, with interviewees simultaneously invoking commercial pressures, regulatory boundaries, international expectations, and strategic state intent, thereby confirming the multi-layered digitalisation dynamics identified in the literature on Chinese hybrid governance (e.g. Lambrou et al., 2022; Zhang, 2020). Together these dimensions described the simultaneous coexistence of cooperation and control, openness and restriction, global participation and domestic protection. Layered hybridity moved beyond existing theories by explaining how digital infrastructures evolved through negotiation between political, institutional, and economic rationalities rather than through linear models of technological modernisation.

The study showed that fragmentation, pragmatism, legitimacy seeking, and structural asymmetry were not anomalies but defining features of digital transformation in state-

influenced market economies. Fragmentation across government support, company adoption, and data governance reflected distributed authority and competing incentives. Pragmatism operates as a dominant organising logic, where actors continuously balance cost, benefit, and compliance. Legitimacy functions as a strategic currency for both the state and companies engaging in global forums, and structural asymmetries between ownership and regulatory authority explained the uneven and contested nature of adoption. This interpretation synthesises empirical evidence across Sections 5.2 to 5.4 and aligns with broader academic perspectives on hybrid and contested governance in China's digital economy (Wang, 2021). In other words, these dynamics redefined digitalisation as a process of negotiated governance rather than a purely technological evolution.

The research refined four theoretical traditions. Developmental state theory was extended to include legitimacy building as a form of state intervention. The technology-organisation-environment framework gained a new dimension through the recognition of ownership asymmetry as a determinant of adoption. Data governance theory was enriched by identifying mistrust as a central organising principle and by showing that sovereignty operated through contracts as well as through legislation. Institutional theory was advanced by demonstrating that fragmented participation could produce influence and legitimacy even in the absence of systemic coherence. Each of these contributions emerges directly from the empirical findings in Chapter Five and the theoretical integration presented in Chapter Six, thereby closing the four research gaps outlined in Section 2.5. The integrative framework of layered hybridity offered a transferable analytical lens for examining other politically complex digitalisation processes, particularly in contexts where state strategy, technological ambition and commercial pragmatism collide.

In conclusion, this study contributed to theory by explaining how digital transformation unfolds in hybrid political economies where state strategy, institutional legitimacy, and commercial reasoning coexist. The research bridged macro-political, institutional, and organisational levels of analysis to show how digitalisation was co-produced through negotiation rather than imposed through hierarchy. The framework of layered hybridity provided both explanatory and comparative potential beyond the Chinese case, offering a foundation for future research on how states and companies jointly shape digital

infrastructures under conditions of regulatory diversity and geopolitical competition. The next section developed the practical implications arising from this theoretical synthesis.

7.4 Managerial and Policy Implications

Beyond its academic contribution, this research offered significant implications for managerial practice and policy design in the maritime and logistics sectors. The findings indicated that the digital transformation of logistics required not only technological capability but also organisational adaptation, regulatory alignment, and cultural understanding. The study showed that the diffusion of smart container technologies in China was not constrained by the absence of innovation but by asymmetries of ownership, fragmented coordination, and limited trust in data exchange. Findings in Chapter Five, Sections 5.2 and 5.3, demonstrated how ownership structure and data governance norms consistently overrode pure technological considerations, confirming the non-technological barriers identified in Chapter Six. Consequently, effective business transformation in the logistics industry depended on combining digital readiness with institutional and relational preparedness. This conclusion is reinforced by grey-literature evidence (Section 1.5) demonstrating that although China controls more than ninety-five percent of global container manufacturing and possesses one of the world's largest shipping fleets, its domestic smart container deployment remains comparatively limited relative to industry leaders such as Hapag-Lloyd and ZIM.

For international logistics companies, the research demonstrated that engagement with Chinese partners demanded a high level of awareness of China's regulatory and institutional environment. Companies that planned to digitise container operations involving Chinese assets or supply chains needed to prioritise compliance assurance above all else. In practical terms, this could mean dividing digital environments for assets located or circulating within China from those operating elsewhere, to avoid data governance conflicts resulting from geopolitical tensions and domestic regulatory constraints. Compliance strategies had to account for China's data sovereignty framework, including data localisation, state-access provisions, and restrictions on outbound data transfer. Companies that recognised these requirements and designed systems capable of operating across separate regulatory domains were more likely to sustain continuity and legitimacy. A managerial recommendation is therefore to invest in

compliance-by-design architectures that can segment data flows at the system level and automate adherence to jurisdictional rules, reducing operational risk and increasing resilience. This need is further highlighted in the Section 1.5 that major Chinese manufacturers such as CIMC are state-controlled and increasingly embed digital capabilities directly into new container builds, thereby placing compliance and security expectations at the point of production. This recommendation to invest in compliance-by-design architectures is supported also by Section 5.3, where interviewees described compliance as a prerequisite for operational continuity, and reflects the broader patterns of sovereignty-driven digital governance discussed in Chapter Two.

The asymmetry of asset ownership could be also not unique to China but a structural feature of the global logistics industry. Differences between owners, operators, and end-users of containers, and other transport assets create varied expectations and requirements for digitalisation. For example, leasing companies, as was demonstrated in this study could postpone digitalisation decision due to the lack of the justifying use case, while operators prioritised service visibility, cargo condition, and real-time data exchange with customers. These divergent needs implied that digitalisation strategies should be differentiated according to asset function and control, rather than based solely on technological capacity. Companies therefore needed to design tiered digitalisation models that reflected the economic logic of asset use, ensuring that technological investments created value for all parties involved. Addressing ownership asymmetry in this way was essential for achieving scalability, interoperability, and shared returns from digital transformation. Given the structural rigidity of container ownership models, the more realistic solution is to introduce operational-process incentives, for example, integrating digital features into service-level agreements, offering digital visibility as part of premium cargo products, or embedding IoT functionality into maintenance and repair value chains. These mechanisms work within existing commercial structures and do not require altering cost-sharing formulas that the industry is unwilling to renegotiate. The operational-process incentives suggestion directly follows from Findings Section 5.2, where operational realities and divergent incentives between owners and operators were consistently identified as the central inhibitors of adoption. Industry evidence confirms this challenge: despite China's dominance in manufacturing, global digitalisation momentum is being driven by Western carriers such as Hapag-Lloyd and ZIM, which

have adopted full fleet smart container programs using Western IoT providers (Section 1.5). This reinforces that adoption decisions are shaped more by business incentives and ownership structure than by manufacturing control.

At the organisational level, the study suggested that logistics companies needed to move from viewing digitalisation as a technological enhancement towards embedding digitalisation within their strategic, financial, and cultural systems. Long-term competitiveness depended on the ability to integrate IoT-generated data into predictive analytics, performance management, and customer value creation. This transformation required investment in skills, cross-departmental data literacy, and information governance rather than in hardware alone. A specific recommendation is to establish internal digital governance councils that coordinate technology, compliance, finance, and operations, ensuring that digitalisation is integrated across organisational boundaries rather than implemented in isolated units. The findings also indicated that the reduction of ownership asymmetry between operators and lessors through restructured contractual arrangements, shared-benefit models, or data-leasing schemes could stimulate broader adoption. Business transformation therefore needed to prioritise value-sharing mechanisms that aligned incentives among the multiple actors in the supply chain. Grey literature analysis supports this implication: as Western carriers scale smart container programmes into millions of units, IoT-enabled operational baselines, such as predictive maintenance and enhanced cargo-visibility products, become industry expectations rather than optional services (Section 1.5). Organisations unable to embed data governance and predictive capabilities risk competitive disadvantage. These managerial implications correspond to the organisational themes in Section 5.4 and the Discussion in Chapter Six, which emphasised that digital transformation succeeds only when embedded within governance structures and operational culture.

For technology providers, the findings underscored the importance of aligning innovation with regulatory compliance. In the Chinese context, technological advancement was inseparable from governance, and commercial success depended on demonstrating conformity with national standards and data security laws. Providers that operated in China were expected to develop local partnerships, joint ventures, or data-hosting arrangements that adhered to domestic legislation. The preference for domestically produced IoT devices was likely to persist, as this choice reflected both policy objectives

and institutional trust in local supply chains. Technology vendors should therefore pursue "compliance-first" product lifecycles, designing hardware and software that can be certified under Chinese standards and that embed auditability, local hosting capacities, and transparent data-handling processes. To remain competitive, international vendors needed to demonstrate technical transparency, auditability, and compatibility with Chinese standards while providing data services that supported traceability, accountability, and environmental efficiency. Chapter One, Section 1.5 indicates that Chinese producers such as CIMC and BoxPlus are increasingly integrating proprietary digital systems into container builds, while Western IoT vendors dominate international deployments. Findings Section 5.4.2-5.4.5, where interviewees emphasised domestic preference, auditability, and jurisdictional security as central determinants of provider selection, correspond to the need of the vendors to be transparent on standardisation work. Technology providers must therefore anticipate a bifurcated technological landscape: one aligned with Chinese regulatory requirements, and another shaped by Western carrier expectations.

For policymakers, the research showed that cross-border interoperability in logistics required not only technological harmonisation but also mutual recognition of governance and trust. Technical standards alone were insufficient to ensure interoperability without institutional mechanisms for compliance assurance, accountability, and regulatory cooperation. Governments needed to promote dialogue between authorities, industry actors, and international standardisation organisations such as ISO and UN/CEFACT, and to develop shared certification models and trusted data exchange protocols that could reconcile national sovereignty with international collaboration. The study also indicated that symbolic or limited funding initiatives were insufficient to accelerate adoption. More effective policy instruments include targeted fiscal incentives for interoperable data platforms, regulatory sandboxes for cross-border data exchange, and multi-jurisdictional pilot corridors that test trust frameworks under real conditions. The professional literature highlights that ISO TS 25287 and revisions to ISO 830 are formalising smart container functionality as an emerging global standard (Section 1.5). Policymakers must therefore anticipate increasing institutionalisation and ensure that national rules do not isolate domestic actors from evolving global digital infrastructure norms. Increase of the effective policy instruments, sandbox programmes and multi stakeholders pilot corridors

suggestions reflect the findings in Sections 5.4 and 5.5, where participants described both the limits of symbolic government support and the centrality of trust frameworks for enabling international operability.

Over the longer term, both industry and government needed to shift from a narrow emphasis on device deployment towards a systemic vision of digital ecosystems. Digitalisation had to be recognised as a collective transformation involving standards alignment, shared governance, and cross-sector learning. For China, this implied closer coordination between ministries, research institutions, and enterprises to harmonise domestic and international standards. For global actors, it required patience, partnership, and an informed understanding of China's hybrid governance model in which innovation and control coexisted. The future direction for the logistics sector, in China and internationally, lay in the creation of trusted, transparent, and interoperable data infrastructures that enhanced resilience, competitiveness, and sustainability. Strategically, this requires policymakers and industry leaders to treat interoperability not as a technical outcome but as a governance challenge that demands alignment across institutions, technology architectures, and legal systems. Grey literature evidence shows that smart container programmes are scaling rapidly among Western carriers and port operators, which means that logistics ecosystems will increasingly expect real-time visibility as a baseline capability rather than a premium service (Section 1.5). This systemic view aligns with the layered hybridity framework developed in Chapter Six, which demonstrated that durable digital transformation emerges from the interplay of state ambition, commercial pragmatism, data sovereignty, and institutional contestation.

In summary, the study confirmed that the digital transformation of logistics was as much an organisational and regulatory challenge as it was a technological one. Future progress depended on companies developing the managerial capacity to operate across different regulatory systems, on technology providers embedding compliance within innovation, and on policymakers fostering trust-based governance frameworks. The alignment of these elements, technological, institutional, and relational, would determine the pace, quality, and inclusiveness of global logistics digitalisation in the years ahead.

Finally, the findings implied that the transformation of the logistics sector required leadership willing to balance innovation with regulation and to build bridges between

national and international digital ecosystems. Companies that learned to adapt to fragmented governance landscapes and policymakers that encouraged transparency, predictability, and interoperability would shape the next phase of digitalisation. The future of global logistics therefore depended on the collective ability of institutions, companies, and governments to align economic ambition with technological responsibility and geopolitical reality. This conclusion integrates the empirical insights of Chapter Five with the theoretical analysis of Chapter Six, reinforcing that managerial and policy transformation must be informed by the hybrid governance dynamics at the core of digitalisation in China.

7.5 Addressing Quality Criteria of the Study

The methodological integrity of this study was ensured through a multi-layered approach to quality evaluation, drawing on Guba and Lincoln's (1989) criteria, Yin's (2014) standards for case-study validity, Silverman's (2017) guidance on qualitative rigour, and Mayring's (2014, 2015) quality principles of qualitative content analysis. Together, these frameworks provided complementary assurance of credibility, transferability, dependability, and confirmability, while maintaining intersubjective traceability, rule-governed procedure, argumentative validation, communicative validation, and triangulation. Within the constructivist and interpretivist orientation of this research, quality was therefore understood not as a static attribute but as a reflexive process grounded in transparency, dialogue, and theoretical consistency.

Credibility was pursued through triangulation between primary interview data, secondary literature, and policy documents, ensuring that the study's interpretations were substantiated by multiple sources (Yin, 2014). The bilingual research design contributed additional depth: all interviews were conducted in Chinese and translated into English, with Ms YinYing Kong providing cultural validation of meanings. Independent bilingual coding was conducted to ensure that conceptual consistency was maintained at the source-language level, reducing interpretive distortion. The resulting intercoder reliability coefficient, Krippendorff's $\alpha = 0.616$, indicated substantial agreement across coders (Krippendorff, 2018), supporting the internal coherence of the thematic structure. In line with Mayring's (2014) criterion of procedural reliability, the codebook was systematically developed, revised, and applied using explicit coding rules. All coding

decisions were recorded in analytic notes, allowing the reasoning behind theme formation to be reproduced and audited (Miles, et al., 2019). These procedures established a transparent analytical chain from data to interpretation, thereby strengthening the study's credibility.

Transferability was enhanced through the presentation of detailed contextual accounts of Chinese digitalisation practices, which enable readers to assess the applicability of findings to comparable contexts (Lincoln & Guba, 1985). The study's evidence of hybrid governance structures, where state ambition, market pragmatism, and institutional selectivity intersect, provided insight relevant to other emerging economies pursuing state-guided digital transformation. The layered hybridity framework developed in the Discussion Chapter Six offered a conceptual lens through which similar national trajectories could be compared, thereby extending the reach of the research beyond its immediate empirical setting.

Dependability was achieved through rigorous documentation of all methodological stages, from data collection and transcription to thematic synthesis and theoretical integration. Following Mayring's (2015) principle of intersubjective traceability, each stage of the analytic process was explicitly defined and consistently applied. Coding procedures were conducted in a rule-governed manner, and reliability was tested through independent replication by Ms Kong, ensuring that thematic patterns did not depend on a single researcher's interpretation. The results of the intercoder reliability assessment confirmed that meaning was consistently interpreted across linguistic and cultural contexts, thereby validating the stability of the thematic categories. Cross-checking was further reinforced by iterative discussion between coders and by triangulation with literature on Chinese digitalisation, which served to challenge potential confirmation bias (Schreier, 2012; Guest et al., 2012). Dependability, thus, rested on procedural transparency and on the systematic validation of analytical consistency over time.

Confirmability was maintained through a reflexive awareness of positionality and potential bias. The principal researcher, examining Chinese governance structures, acknowledged the interpretive asymmetries inherent in cross-cultural qualitative research. Reflexive notes recorded throughout the data-collection and analysis phases documented instances where interpretation was uncertain or culturally contingent.

Communicative validation was achieved through recurrent discussion with Ms Kong and through peer debriefing within the research supervision process, which together served to interrogate interpretive assumptions and ensure that conclusions remained grounded in participants' perspectives (Altheide & Johnson, 2011). The inclusion of direct quotations from interviewees throughout the Findings Chapter Five further satisfied Mayring's (2014) requirement for argumentative validation, providing textual evidence for each interpretive claim and allowing readers to evaluate the logic of inference.

These criteria were treated as mutually reinforcing mechanisms ensuring the overall trustworthiness of the study. The integration of Guba and Lincoln's (1989) dimensions with Mayring's (2015) procedural standards produced an evaluative framework that combined epistemological coherence with methodological rigour. The bilingual coding procedure exemplified communicative and procedural reliability; the transparent development of the codebook satisfied the requirement of intersubjective traceability; and the systematic cross-checking of interpretations ensured argumentative validity. Triangulation between empirical data, theoretical frameworks, and international case studies, such as Hapag-Lloyd's and ZIM's full fleet digitalisation programmes, further reinforced the interpretive robustness of the analysis by situating Chinese practices within global reference points.

Overall, the study's quality assurance practices reflected the interpretivist understanding that credibility emerged through transparency and reflexivity rather than numerical precision. By adhering to the complementary frameworks of Guba and Lincoln (1989), Mayring (2014, 2015), and other established methodological authorities, the research demonstrated reliability, validity, and communicative coherence consistent with the epistemological stance of social constructivism. The procedural transparency of coding and cross-checking, the theoretically informed interpretation, and the reflexive recognition of positionality together provide confidence that the findings were both trustworthy and transferable, offering a rigorous and well substantiated contribution to understanding China's approach to container digitalisation.

7.6 Limitations and Areas for Future Research

As with any qualitative study, this research has certain limitations that delineate the scope of its findings. Firstly, the sample size and the focus on the intermodal container digitalisation experts, though appropriate for an exploratory study, cannot represent the full diversity of China's logistics ecosystem. The participants were senior actors drawn from shipping lines, manufacturing, IoT development and national standardisation. While this provided high-level insight, this study did not fully capture the perspectives of regional carriers, privately owned SMEs, operational personnel or provincial authorities, whose experiences may differ from national or globally oriented organisations. These additional voices might have offered further nuance into localised digitalisation practices and the uneven diffusion of IoT technologies across tiers of the sector.

Secondly, given the political sensitivity surrounding data governance and international standardisation, participants may have adopted cautious positions, particularly when discussing issues linked to compliance or sovereignty. The fact that the interviews were conducted in Chinese strengthened, rather than constrained, the quality of the data. Using the participants' native language fostered openness, reduced social distance and enabled interviewees to articulate institutional reasoning with clarity and nuance. The subsequent bilingual verification undertaken with Ms YinYing Kong confirmed that the transcripts contained no semantic misunderstandings or translation distortions. The bilingual coding process therefore enhanced cultural accuracy and interpretive precision within the analysis.

Thirdly, the findings represent a snapshot in time within a rapidly evolving technological and geopolitical landscape. Developments in artificial intelligence, blockchain, machine-to-machine communication, and international regulation continue to reshape the sector. Geopolitical tensions, sanctions regimes and China's shifting data sovereignty policies (including the DSL and PIPL) also influence corporate behaviour. Patterns identified in this study may therefore evolve quickly, and insights derived from interviews conducted during the research period may not generalise beyond similar regulatory and political conditions.

Fourthly, methodological constraints must be acknowledged. This study adopted a constructivist, qualitative design using semi-structured interviews and thematic analysis.

While appropriate for understanding meaning-making and institutional interpretation, the analysis cannot quantify adoption rates, performance outcomes or cost structures. Thematic depth was prioritised over breadth, and the study did not include quantitative models, survey-based triangulation, or objective performance indicators. This might limit the ability to evaluate causal relationships or measurable operational impacts.

However, despite these limitations, the study generated valuable empirical and conceptual contributions. The participants represented the core decision-making centres within China's smart container ecosystem, like shipping lines, manufacturers, IoT providers and standardisation authorities, allowing the research to access the institutional logics that shape national digitalisation. Methodological rigour, particularly bilingual coding and intercoder reliability, ensured analytical robustness. The thematic patterns revealed systemic characteristics, such as layered hybridity, sovereign data governance and selective adoption, that offer explanatory insight beyond the immediate sample.

To address the limitations identified, future research should pursue the following priorities. Firstly, empirical breadth should be expanded to include regional, provincial and mid-tier actors within China, as well as privately owned logistics companies whose incentives and constraints differ from state-linked entities. Secondly, longitudinal studies should be undertaken to trace the evolution of policy, adoption behaviour and technological maturity over time, particularly as AI-driven automation becomes integral to global logistics. Thirdly, comparative analyses between China, the European Union and the United States would illuminate how distinct governance systems shape digitalisation trajectories and the politics of interoperability. Finally, future research should integrate quantitative indicators, such as adoption rates, cost-benefit models, interoperability indices or network performance metrics, to complement qualitative depth with empirical scope. This mixed methods approach would support stronger generalisation and strengthen theoretical contributions to digital industrial policy. Together, these future directions would extend the global understanding of digital supply-chain governance and contribute to the development of comparative digital-industrial policy theory.

7.7 Final Summary and Reflective Conclusion

This study examined how China navigated the intersection of technological innovation, industrial policy, and data sovereignty in its approach to container digitalisation. The research demonstrated that China's strategy was neither purely state driven nor entirely market-oriented but a pragmatic synthesis of ambition, experimentation, and constraint. By combining theoretical rigour with empirical insight, the study contributed to a deeper understanding of how digitalisation unfolded within distinctive governance systems and how these systems shaped the balance between openness and control. The concept of layered hybridity provided a theoretical foundation for future comparative research and confirmed that digital transformation was as much a political and institutional process as it was a technological one.

Across the applied theoretical frameworks, a central pattern of dualities and cross-cutting pragmatism emerged. The Chinese case demonstrated that ambition and restraint, openness and control, and global aspiration and domestic protection coexisted in constant negotiation. These dualities were not evidence of policy failure but intrinsic characteristics of a developmental system adapting to global digitalisation. The integrated analysis reaffirmed that China's smart container strategy represented a form of structured ambivalence and advanced the concept of layered hybridity as both a theoretical and empirical contribution. This concept enabled the interpretation of overlapping logics of state, market, and institution that interacted to produce hybrid outcomes, contributing to broader debates on governance in global digitalisation and demonstrated that transformation in logistics was neither linear nor uniform but contingent, negotiated, and politically embedded.

The research highlighted the evolving nature of global logistics in an era increasingly defined by digital sovereignty and geopolitical complexity. China's experience offered insights for other economies seeking to achieve digital integration while maintaining regulatory autonomy. The findings illustrated the delicate balance between innovation, control, and collaboration that underpinned the digitalisation of global supply chains and emphasised the need for harmonised governance frameworks capable of accommodating technological and political diversity.

Theoretically, the study contributed by refining developmental state theory, extending the technology-organisation-environment framework, enriching data governance theory, and nuancing institutional theory. The research demonstrated that developmental state intervention operated through legitimacy building rather than fiscal mobilisation, technology adoption in asset-intensive industries reflected ownership structure as much as readiness; sovereignty was enacted through corporate practice as well as regulation; and fragmented participation in standardisation could create influence without structural convergence. These insights collectively advanced the four theoretical traditions used in the study and provided a holistic explanation for the layered hybridity observed in China's digitalisation trajectory.

Empirically, the research provided detailed evidence of ownership asymmetry, institutional fragmentation, mistrust in data exchange, and the symbolic nature of subsidies. This study also identified pragmatic globalism as a distinctive mode of Chinese engagement with the international digital economy, revealing how participation and protection coexisted within a single governance model. This enriched the empirical literature on maritime digitalisation, Chinese industrial strategy, and global data governance.

In managerial and policy terms, the study offered practical guidance for companies and policymakers engaged in logistics digitalisation. This research indicated that business transformation required not only technological investment but also organisational, regulatory, and cultural alignment. Companies operating across jurisdictions needed to prioritise compliance assurance and, where necessary, establish separate digital environments for assets located within China and those operating globally to avoid data governance conflicts. The research also showed that ownership asymmetry between asset owners, operators, and users, whether in China or elsewhere, created differing digitalisation needs that required tailored strategies. Businesses that aligned digital investments with the economic logic of asset use, balanced innovation with regulation, and developed trust-based data frameworks were better positioned to benefit from digital transformation. For policymakers, the study underscored that international interoperability depended not only on technical standardisation but on institutional trust, cross-border governance, and the creation of mechanisms for shared compliance and accountability.

Furthermore, the study showed that digitalisation in logistics was not simply a matter of technological advancement but one of sovereignty, legitimacy, and institutional negotiation. As global supply chains became increasingly digitised, these dynamics determined not only technological adoption but also the distribution of influence and authority within the global economy. The Chinese case thus served as a lens through which to understand the future of industrial digitalisation in politically complex environments.

In conclusion, the study demonstrated, using the example of China, that global logistics digitalisation cannot be explained through technological variables alone. This research is shaped by the interaction of state ambition, company pragmatism, institutional legitimacy, and geopolitical contestation. Digital transformation therefore requires governance structures that can accommodate competing political priorities, fragmented regulatory regimes, and asymmetric industrial incentives.

The study closes by reaffirming that the future of global logistics will be defined not only by the sophistication of its technologies but by the capacity of governments, companies, and international institutions to coordinate and negotiate their use. The ability to align economic ambition with technological responsibility and geopolitical reality will determine the inclusiveness, resilience, and sustainability of digital supply chains in the decades ahead.

Declaration of Authenticity

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except, where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are those of the author and in no way represent those of the University.

I confirm that this dissertation is the original work. The analytical processes and interpretations presented herein were carried out independently by me. Software tools including NVivo and Atlas.ti were used exclusively to support the organisation, coding and management of qualitative data. The automated transcription function in Zoom was used only to generate textual transcripts of the interviews for subsequent analysis. DeepL Translate was used solely to assist with the translation of Chinese language materials into English. All translations were subsequently verified for accuracy and meaning.

Signed Levtov Marianna Date 12.12.2025

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Appendices

Appendix I Letter of Consent, English/Chinese

Letter of Consent / 保密同意书

Principle Investigator / 主要研究人员: Researcher Levtov

Institution / 研究机构: University of Gloucestershire

Interview Details / 采访内容

Interview Number / 采访编号:

Interviewee / 受访者:

Organization / 受访者所在机构 :

感谢您参加 《智能集装箱: 供应链数字化时代下的机会与挑战》研究。本采访是为了分析对智能集装箱的重要看法。讨论的题目是关于设备的产地，数据的交换和标准化过程。所有本次采访中采集到的信息都属于受访者。

采访参与者可以选择以下保密级别:

Participants in this project have the option to select one of the following levels of disclosure for the data collected in interviews conducted for "*Smart containers*: opportunities and challenges in the era of supply chain digitalisation". The interviews will be designed to gain a critical insight into the perspectives and experiences of how containers are tracked globally and the associated challenges and will cover the current trends in smart container adoption, technology origin, data exchange and sharing, as well as the standardisation process.

All data collected as part of the research is firstly considered the property of the interviewee and their preference expressed below will be strictly followed.

信息安全选择/ **Interview Preference Selection**

您是否同意对此次采访进行录音/录影？(请圈出合适的回答)	是	否
Was the consent for recording the interview given? (circle as appropriate)	Yes	No

我希望我的信息能得到以下处理 / I would prefer my data to be used in the following manner:

描述/ Description	请打勾/ **Please Tick One**
1. 完全匿名/ Complete Anonymity (姓名、 职业 、公司名称不被公开/ Your Name, Title, and Company Name are not disclosed)	
2. 可以使用受访者所在公司的名称和职位/ Making use of a Company Name and Job Role of Interviewee (信息可以跟公司名称和受访者所在机构的职位一同使用 / The data is allowed to be used with company name and the organizational role of the interviewee)	
3. 受访者姓名和公司名称完全的公开/ Complete disclosure of interviewee name and organization name	
4. 其他Other (请描述Please describe)	

受访者的姓名和签名Interviewee Name and Signature:

日期Date:

Appendix II Interview Transcripts

Reflective Interview with Ms YinYing Kong (in person, November 06, 2025 – in English)

Purpose of the Reflective Interview

This reflective interview was conducted to support the transparency and triangulated nature of the interpretive process used in this study. Ms YinYing Kong participated as an independent language expert and auxiliary coder for a subset of the original Chinese-language interview transcripts. The following exchange summarises her reflections on accuracy, linguistic interpretation, and the neutrality of the coding process.

Reflective Interview Transcript

Researcher:

Thank you again for supporting the bilingual coding process. To begin, I would like to confirm a procedural point. Do you agree to have your name included in this thesis as the independent language expert who contributed to transcript verification and intercoder reliability?

Ms Kong:

Yes, I give my full consent for my name to be included. My role was limited to language checking and independent coding, and I am comfortable with this contribution being acknowledged in the thesis.

Researcher:

Thank you. Turning now to the substance of your involvement: did you consider the interviews to have been conducted in a manner that respected participant privacy and confidentiality?

Ms Kong:

Yes. All transcripts I received were anonymised. I did not have access to names, positions, or identifiable information. From what I saw, the interviews were conducted ethically, and confidentiality was properly maintained.

Researcher:

Could you reflect on the accuracy of the Chinese transcripts and the subsequent English translations?

Ms Kong:

The original Chinese transcripts contained some automatic transcription errors, which is normal, but these were corrected during our review. After we completed the corrections, the transcripts accurately reflected what the interviewees said. When I compared them with the English translations, I did not find differences that changed the meaning. The translations captured the core ideas faithfully.

Researcher:

From your perspective as a native Chinese speaker, did you observe instances where meaning might have been altered during translation?

Ms Kong:

In principle, Chinese and English can express concepts differently, especially institutional or culturally embedded terms. However, in this study, I did not identify any significant cases where meaning was lost or distorted. The interviews were expressed clearly, and both the Chinese transcripts and the English translations preserved the interviewees' intentions.

Researcher:

You also participated in coding a subset of the transcripts. Did you notice any interpretive bias or influence from my existing knowledge of the topic?

Ms Kong:

No. I am not from the logistics or digitalisation field, and I do not know the interviewees personally, so I approached the material neutrally. When comparing our coding results, the overlap was strong. Any differences were minor and related to phrasing, not meaning. This suggests that the coding instructions were clear and that your interpretations remained anchored in the data rather than shaped by prior assumptions.

Researcher:

Do you believe that the interviewees' views were captured adequately through both the Chinese transcripts and the English-coded material?

Ms Kong:

Yes. Their views were clearly expressed in the interviews. The Chinese transcripts preserved this clarity, and the English versions reflected it consistently. In my assessment, the bilingual coding process captured the meaning accurately.

Researcher:

Thank you. Is there anything else you would like to add regarding the process?

Ms Kong:

Only that the bilingual verification was handled carefully. The stages of correction, translation checking, and independent coding provided a strong basis for accuracy. The process gave me confidence that the analysis represents what the interviewees intended to convey.

Interviewee 1, July 24th, 2024. Zoom Call, preferred language – Chinese (English Transcription). Questions were requested ahead of the interview call.

Researcher:
We do not need any confidential information from your company. As for your personal views on the interview topics, you can just share your opinions based on your past experiences or work. This interview does not involve any commercial trade secrets related to your company's container management. It is entirely for my academic research as part of my doctoral thesis. So, please rest assured on that point.

Interviewee 1:
Okay. In that case, I'll just share whatever comes to mind, not necessarily following the sequence of the questions. First, let me introduce myself. I have always been involved in container management work. Previously, I focused mainly on maintenance and repair. Later, I moved on to container management, and then to container standards and specifications. I hope my speaking pace is okay.

Researcher:
The pace is fine. May I ask, how many years have you been working in this industry?

Interviewee 1:
Hmm. I actually started doing this in 2000, so I've been in this industry for more than 20 years. Comparing now with before, I feel quite emotional about it because there are significant differences compared to the past.

One major difference, which I think is related to your research topic, is the extensive application of digitalization in this industry. It has led to significant changes in workflows and the scope of activities, among other aspects.

Regarding digitalization, let me reiterate that today I am speaking only on behalf of myself, not my company. This is also specified in my confidentiality agreement. You can record this interview, but please do not mention my company's name, alright?

Researcher:
Of course, I understand. I will not mention your company.

Interviewee 1:
Then, regarding (container) digitalisation, it is currently a strategic focus for our company. Ever since the previous leadership took office, there has been a full-scale push to promote digitalisation. This initiative touches on many aspects, including various processes in the market, such as orders and booking spaces. But I'll just talk about the container management aspects that I'm more familiar with.

Regarding container management, we are primarily working on three aspects:

1. **System Development:** The first and most important is promoting digitalization through the overall container management system.
2. **IoT Hardware Installation:** The second aspect involves installing IoT devices on hardware, which I will elaborate on shortly.
3. **AI in Repairs:** The third aspect is applying AI systems for smart repairs, which we have been promoting recently.

Let me start with the first aspect - **system development.** This is mainly being applied in two areas:

- **Container Allocation:** Container allocation is a routine task in container management. It involves determining which containers are available in a specific location, taking into account unloading, loading, and customers returning containers. Previously, this was entirely manual and based on experience. Now, we use a container allocation system. The advantage of this system is that it can automatically calculate when containers will be unloaded, loaded, and the likelihood of customers

returning containers on specific days. It also factors in special considerations like pre-holiday stockpiling and unforeseen events. This has greatly improved accuracy in container allocation.

- **Return of Leased Containers:** For returning leased containers, we are also implementing a digitalized system. This task is more specialized because it involves contract terms, such as the number of containers that need to be returned at each port or location each month. Our company manages a large number of containers, so when it's time to return them, we must prearrange where and how they'll be returned. Now, this process is largely handled by the system. These are the two key areas where we're applying digitalization through our systems.

Next, I'll talk about hardware**.** In terms of hardware, we primarily use IoT devices. These devices are mainly installed on refrigerated containers. Why are they installed on refrigerated containers? It's because, to date, we believe that power supply for the equipment remains a challenge. Refrigerated containers have their own power supply, so we install IoT devices on them to serve customers using refrigerated containers.

Interviewee 1:
What functions does it primarily provide? Mainly GPS positioning. Additionally, it enables real-time transmission of data such as the refrigerated container's temperature, humidity, and gas composition.

This year, we also conducted some trials on dry containers. However, due to the unresolved battery issue, IoT devices on dry containers can only last for about one year.

What are the main application scenarios? For instance, we lease our containers to domestic customers and need to know where these customers are using the containers, as there's always a concern about losses. Because the leasing is short - term, typically a few months, the IoT devices are installed for tracking, but they haven't been widely used yet. This is an example of the hardware application.

The last aspect I'd like to introduce is the digitalisation of repairs**.** In the container industry, every handover, such as customers returning containers or containers being unloaded at ports, involves equipment inspection. Previously, these inspections were conducted manually.

Manual inspection has many pain points. For example, each person at different handover points might follow inconsistent repair standards. During inspections, inspectors often need to climb up and down containers, and adverse weather conditions add challenges to the work's intensity.

Now, we are working on an automated solution. At the gateway, we're deploying a system that uses 2D cameras, somewhat similar to Elon Musk's autonomous driving technology, combining cameras with 3D lidar.

This setup provides full - scale inspection at the gateway when customers return containers. That's the first step.

The system can immediately generate an inspection report and an initial quotation for any necessary repairs. Using our AI - powered inspection quotation system, it automatically processes the data and generates the repair quotation without requiring repeated manual confirmation. This significantly improves efficiency.

That's the overall picture. These are the three areas where our company is advancing digitalization and making attempts. Do you have any questions, or would you like me to elaborate further on any part?

Researcher:
I have a small question. You mentioned 3D lidar earlier, is that the same thing as RFID?

Interviewee 1:
They are different, very different. The 3D lidar is just like a camera. When a container enters, the 3D lidar can measure distances. For example, if there is a dent, it can detect how deep the dent is and determine whether it meets the damage standards.

Of course, let me add something. Like I mentioned earlier, the system can automatically recognize the wear and tear on the container the next time it enters. It can also automatically identify the truck's license plate number and complete some of the electronic processes at the handover point. All of this can be achieved.

Researcher:
Thank you.

Interviewee 1:
Any other questions? I've covered pretty much everything I wanted to talk about. I think you have one more question about standardization, right? Regarding standardization, I haven't fully thought it through because that's a very broad topic.

When it comes to standardization, I think it might involve things like interfaces - standardization of data interfaces. Other aspects, I believe, are already quite complete.

Researcher:
Ah, right. You've talked about digitalization methods and smart technologies. Can I ask you about Germany's new policy? They've implemented a nationwide program to equip every container with IoT devices, ensuring each container can be tracked. Since it's a government-level initiative, what are your personal thoughts on this?

Interviewee 1:
I think our goal, including what we're currently trying to achieve, aligns with this. If it can be realized, it would indeed be very effective. The container supply chain is quite long, and if this system were implemented, communication of information would be highly efficient.

However, I believe there are still many technical challenges. For example, how can real-time tracking for each container, especially dry containers, be achieved? We've been working on solving the battery issue for dry containers, but it hasn't been resolved yet.

From our experience, the maximum we can achieve is a battery life of one to one and a half years, depending on the frequency of daily data transmissions. But once these devices are installed, our dry containers are intended to last for 15 years based on depreciation. If the

batteries have to be replaced every year, the cost would be extremely high, which I think is unrealistic.

That said, we certainly welcome this policy. If many containers could achieve this, it would be very effective. For container management systems, whether it's standardized tracking or monitoring, it would be highly efficient.

Researcher:
To summarize, you believe there are still many technical issues that cannot yet be resolved effectively or at a low cost. I understand. One more question: regarding the origin of the technology providers you use, do you have any personal preferences?

Interviewee 1:
It's like this, each shipping company seems to be very cautious about this aspect. I feel there's a concern about trade secrets in this area. So, at least for our company, that's the case. I won't speak for other companies, but all the technology we use, our IoT devices and systems, is developed in-house by our company. It's like that because of the involvement of trade secrets.

Researcher:
Right, right. Oh, one more question about government subsidies. I'm curious whether your industry, or your company specifically, receives any government subsidies in China?

Interviewee 1:
There are some subsidies, yes. But I'm not too familiar with the specifics. I have previously handled applications, though.

Basically, you apply, and since it's considered a high-tech industry, the government approves the subsidy. The process is relatively easy, but the amount isn't very large, usually in the

range of hundreds of thousands of RMB. For a shipping company, this amount is quite minimal.

For example, we're currently working with the National Standards Committee (国标委 *guobiaowei*, National Standards Committee) on some system promotion projects. Their funding model is like this: for each task, they can provide up to about 500,000 RMB. If a company wants to collaborate with the government on a project, the government can contribute up to 500,000 RMB, but the rest of the costs must be covered by the company.

However, as long as the project is innovative, involves something that hasn't been done before, and falls under high-tech or digitalization, it's relatively easy to secure funding from the government.

Researcher:
Hmm, okay, understood. One last question: regarding the standardization efforts you mentioned earlier, has your company participated in any standardization organizations? If so, why did you choose to participate in these organizations?

Interviewee 1:
Ah, here's the thing. We are part of an organization called COA, I don't know, Researcher, are you familiar with it?

Researcher:
Yes, I am.

Interviewee 1:
So, we participate in that. Our company also has a subsidiary called Box Plus, which works on IoT. It's one of the drafting units for several IoT - related standards. That's one part.

The second part is the National Standards Committee (国标委), which is China's National Standards Committee. Through this, we also participate in ISO activities. Yes, this is another area where we're active.

Previously, some of the work we did seem to be related to CIMC, specifically in areas like QR codes for containers and some other standards. We collaborated with CIMC on those. However, we weren't very involved in that part before.

Recently, we have been participating in the revision of a standard related to container repairs. The revision is about updating a previous version.

During the revision process, we aim to include AI-based container inspections and standards related to digitalization, creating a foundation for more forward-looking developments. We plan to finalize these standards. Beyond that, there isn't much else. Do you have any other questions?

Researcher:
Hmm, that seems to cover most of it. One last question about data: How does your company use the data collected from smart containers?

Interviewee 1:
Ah, yes, yes, I actually mentioned this earlier. For refrigerated containers, the data is mainly used for tracking. They collect GPS data, along with temperature readings from the intake and exhaust vents, humidity levels, and gas concentration data inside the container. These are the primary types of data collected by refrigerated containers and transmitted via our IoT system.

This involves communication protocols from suppliers. Some suppliers are willing to open their interfaces to us, while others are not.

For dry containers, the data primarily consists of GPS tracking. Oh, and there's also anti-theft functionality. On both dry and refrigerated containers, we've installed anti-theft switches on the doors. When the door is opened, it generates data and triggers the anti-theft device.

So, as I mentioned earlier, these are the main types of data. There might be other uses, like for booking or related processes, but I haven't been directly involved with those.

Researcher:
Right. So, do you share this data with your customers, or does it depend on the specifics of the agreement?

Interviewee 1:
We generally don't share it (data) unless the customer is willing to pay. We provide this as a paid service. I think I've covered everything I wanted to say. Do you have anything else to ask?

Researcher:
No, this is really great. I think we've covered everything, and it was all very thorough. Great, thank you so much

Interviewee 2, September 13th, 2024. Zoom Call, preferred language – Chinese (English Transcription).

Researcher: Hello, Professor (Name).

Interviewee 2: Hello, how are you? Can you see me?

Researcher: Ah, yes, thank you, you're in Australia now, aren't you?

Interviewee 2: No, I'm in China, I didn't go to Australia.

Researcher: So, this is a good time for you, right?

Interviewee 2: Yes. And why are you, why are you doing this interview?

Researcher: I'm doing my PhD at a university in the UK, and I need to do a lot of (relevant) interviews for my PhD thesis.

Interviewee 2: Where are you doing your PhD? Why are you doing this thesis?

Why did you do this subject? Because I've been in this industry for more than eight years now, so I know better and understand the meaning of IOT and the meaning of smart containers. I've been working with Prof. (Name) in the ISO organization since 2020, so that's a better understanding of the industry. Then, I studied Chinese as an undergraduate, so I hope to combine my research and understanding of China with my major, and also, there is not a lot of research in this area, so it's a very interesting and interesting thing for me to do. In order to complete this doctoral dissertation, the university requires us to conduct some interviews. There are two questions I would like to ask about this interview before we start: first, how do we mention your workplace? Because I still don't understand how to indicate your work unit and position in my dissertation.

Interviewee 2: The organization is (Name of Organisation).

Researcher: "(Name of Organisation), okay,

and how do I describe the position?

Interviewee 2: The position is similar to General Manager.

Researcher: Similar to General Manager, yes, because I heard that you also serve as a professor, so do you want to use another position, or do you think you should use the "General Manager" position that you just mentioned?

Interviewee 2: Yes, that's fine. I am also a professor at the university.

Researcher: It's better to use your business position, right?

Interviewee 2: Yes, both are fine.

Researcher: Okay, thanks. Okay, so if you don't have any other questions, why don't we just get started? I've prepared three areas of questions, you (should) have already read them, this first area (of the interview questions) is (about) intelligent digitization of containers. Then I'm going to ask the questions directly. The first question is about the intelligent digitalization of containers, how do you use or how do you carry out the digitalisation of containers in your organization, or in the industries that you've been in contact with? What are the means?

Interviewee 2: Now actually for the container project automation, now for the user, their needs, I think, are similar, now need to know the location of the container, and then need to know the status of the container ah, now every enterprise is basically these things.

Researcher: Yeah. Mainly to understand the location and status of the container, yes, so for the container digitalization, intelligent main specific use (what)? For example, how to realize the collection of data on the location and status of containers.

Interviewee 2: these different enterprises, its needs are not the same, it is based on, for example, box east ah, or logistics enterprises ah, yard ah, it to these digital data are not the same. For example, the yard, it may need to know the status of the container to some, especially reefer containers. But for some logistics companies, it may be more need to know basically the location, right? Then for those customs, he needs to know some of the container customs clearance declaration, he is all aspects. So, this (information) collection, now basically through the GPS and the terminal 4G terminal to do data collection, right?

Researcher: Okay, thanks. So, the next question is. Germany recently passed a new decision to use IoT to track every container, so what are your thoughts on this new regulation?

Interviewee 2: Why did Germany adopt this regulation? What is the background of the development?

Researcher: Background? I know, it's the Hapag-Lloyd study, they have been considering it for more than three years, they need one IOT device per container or one.

Interviewee 2: Hapag-Lloyd is the shipping company's business, it's not a German national policy.

Researcher: No, the company is in Germany, so they are ......

Interviewee 2: I know. Hapag-Lloyd, because it is invested in that one company well, the cooperation of the company Nexxiot and Orbcomm. that it is a reefer container or dry container? Or is it all containers.

Researcher: All (containers).

Interviewee 2: I know, I know. This I know is not Germany, this policy is every shipping company, such as MSC or Hapag-Lloyd or COSCO, everyone is doing this. But now, for example, like China COSCO, mainly focusing on cold boxes, but Hapag also said that each of his containers, including dry containers have to be installed on the words of this, I do not know if it is dry containers, the technology is not mature ah, etc., this time to see, (but) this is certainly a trend. Because for container management, is this a trend? But we'll see how far it goes. This is something that was talked about ten years ago, twenty years ago.

So you think it's a trend. But we'll have to wait and see if it's technically mature and how far we can push it forward, won't we?

Interviewee 2: Yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes, yes.

Researcher: Yes, but what do you think?

Interviewee 2: This hasn't paid for itself yet! This I know, in fact, many years ago is that we want to know the location of each container, it is inevitable, but our current technology, means, I think it is difficult to say, right, the current technical means, it is not a good means as just

said, he cannot return to the capital, right? As for whether there will be cheaper means in the future under this kind of demand, I think it is possible, right? Like we started to do this WeChat payment ah, do micro-payment, that we started to use the technical means are not our today's two-dimensional code technical means. We used to use very high-cost technology to realize micropayments, and then, we used very cheap cost to realize micropayments. Well, I think the container is the same, we are now using a very high cost in the realization of container tracking, so he cannot return to the capital, so he is a very high cost, its cost is not just a single investment cost, it is the main problem or the maintenance of the cost is very high, right? It is equivalent to our in each container installed a smart terminal or, this smart terminal maintenance cost is very high, this terminal should be maintained by who to the problem. So, after the introduction of these policies, who will ultimately bear the cost? This is to play a question mark, right? So, for some small-scale container box owners is possible, for example, one, two thousand, tens of thousands of ah this kind of, for example, this local area category, such as some routes is possible, like Hapag-Lloyd such a global large-scale this kind of way, it is difficult to say whether it can afford this cost. Because I know that the op account sells equipment to them and sells services to them, and the outbound itself is going to charge a fee, and that's going to be paid by Hapag-Lloyd, so the money that Hapag-Lloyd earns might not be enough to pay for it, and then the business model won't be viable.

Researcher: Okay. And then the fourth question, in order to digitally smarten the containers, what are some of the technologies that you've used so far, like IoT devices, or a RFID tags, etc. Why are you using these technologies? Why do you use these technologies?

Interviewee 2: Now we have used all the technical means, for example, the beginning is to use RFID tags, later is to use the GPS terminal, and then Orbcomm satellite this set of means, we have also tried, including now 4G, including now NBIoT ah, but all in all, now do not have a good technical means, right? Including the cost problem, including the problem of communication, including the core or battery problems, and so on, in the future there will be some problems with the international law, right. Because now basically after installing a smart terminal, it has actually changed the shape of the container, so this is something that will need to be in the future in the ISO is we going to have a new type of standard for the box, to be certified by the pass-through, and that's probably not even close to that right now.

Researcher: That's clear, okay, thanks. Then the fifth question is, about these suppliers other than these technical means that you just mentioned ah, what other technical suppliers would you consider other than the ones that you've used so far and why?

Interviewee 2: Now it's just a few suppliers ah, now it's what Orbcomm track since ah, and then there's also a there's a U.S. what's called Globetracker, right? Then the Chinese, like what, that HaiLuZhiTong ah, China West Intelligence ah, all over the world to do this, just so a few companies. I don't know about Israel, that company is still there, and now these companies, I think it's hard to say, the future development of the technology, because I don't think the current technology is not the final technology.

Researcher: Understood. And do you have any preference when you choose these suppliers, like any consideration for the country of origin, country of origin? For example, is made in China preferred ah, made in Taiwan ah, made in the U.S. or made in Europe do you have any considerations in terms of this origin?

Interviewee 2: In fact, the intelligent basis of the application, the origin is it does not need to consider the factors, it has to consider the factors, the first is the price of the problem, the second factor to consider, is the digital management of the problem, that is, digital in the end how to manage? Because op account those things it is impossible to use in China. Because op account those things, it's, the data is sent directly to its U.S. servers, and then by the U.S. servers and then transferred to the user, that this future in the container global application will encounter problems, because this container to put it bluntly, it is a cell phone. Right? That is a cell phone, so the use of this cell phone, right, for example, our cell phone, to the United States we may be to accept to the United States of this server inside we arrived in Germany to access to the German server inside the same, so this future data interconnection, which is to be resolved. You say Hapag-Lloyd kind of way to install a smart terminal after the arrival of China, if the scale up, will encounter legal obstacles in the future? I think it's hard to say.

Researcher: Right. Okay, thank you, so let's quickly move on to the sixth question, which is, with regard to the data collected by the smart container, how does your organization use the data so far?

Interviewee 2: We don't use the data now; we collect the data and give it directly to the users. We do whatever the users ask us to do.

Researcher: So, you don't process the data, you just collect it and give it directly to the customers. And then do you have a program like that in your organization? It's to share this data with freight forwarders, ports or authorities, or shippers. What is your current agreement?

Interviewee 2: We don't have one at the moment. The problem with the numbers is that we are a service provider, so we provide the data to whoever we collect it for. We're not doing the sharing and processing of this digital ourselves, and I think it will be the same in the future. The data collected can be shared by him (the customer) within the scope of the license, for example, it is basically the shipping company that is doing this now, and after the company collects his data, it should share it with his forwarder, his yard, etc., and with his cargo owner, right? So basically, in this area, it's the shipping companies or the owners themselves, the shipping companies, the logistics companies are doing this.

Researcher: Understood, okay, so we're done with the first two parts of the questions, and the last part is about standardization, and there are three (specific) questions about what standardization organizations your company is currently involved in or is involved in? Why did you choose to participate in these organizations.

Interviewee 2: Ah, the container piece, it's only an ISO TC104/ SC 4 organization, right? There is no other organization. There is only one organization, right?

Researcher: Yes, Professor Zhou you mean there is only one organization, so there is no question of which standardization organizations.

Interviewee 2: I know now it's the ISO organization piece, now everybody is involved in some standards, but actually ISO plays not a particularly big role. You see, we have been doing ISO standards for so many years, but also came out a lot of standards, (like) 18885 ah, 18886 ah, made a good standard, in fact, these standards are not in the industry to get the application of ah.

Researcher: Now we are starting very new standards now. I'm hoping that in two years it will be adopted. So, are there any other organizations, like in Europe or .....?

Interviewee 2: Ah, yes, yes, yes, this WCO, this has a lot of organizations, yes, now this piece also depends on it, right? Now because the whole situation is different from ten years ago, right? So the cooperation between the international ah, standards between the interoperability is not like before so we all have a consensus, right, now may not be as easy as before.

Researcher: Yes, is there any special standards organization in China?

Interviewee 2: We have our container standardization committee. We have a special organization to do this. These are the national committees that are interested in, they are interested in what the technology is. Nowadays, none of the technologies are actually OK. What about the satellite, Musk's Starlink? He is also not OK, and then 4G this set of things is also not OK but this set of things just in China (feasible), it is not OK in the world, so the current technology is not very perfect, are not very ideal. I think the future of smart containers should not be realized in the current way.

Researcher: What you mean is that the current technology is not perfect, or it is only locally feasible, it is feasible in a certain area, but it is not ideal. But I hope that two, three years from now we may use this lower wide satellites. i agree with you Professor Zhou, yes, for me, the current equipment is not too smart, three years from now we find a new way. after Covid, Hapag-Lloyd uses their money to buy the new equipment. This is a different situation than later, so we'll see where it goes from here. Then basically we have the same idea that none of the current technical means are ideal. That brings us to the last question, which is about government subsidies, and that is in your opinion. Container digitization in China's environment, to what extent has it been subsidized by the government? Is there any subsidy?

Interviewee 2: There are subsidies for research projects. In fact, container digitisation, we can apply for some research projects, but the group itself is not subsidised. Container itself, the smart container itself is not subsidised. Now why our smart container on the return on investment cannot be recovered, in fact, because our current business model did not find a good solution. Now shipping companies do this smart container, the shipping company - it's container management, it's logistics, supply chain management, it is more mature, so from the inside to find the return on investment is very difficult. So, we must look for the new value, new points, it is possible to find the return on investment. Now the shipping companies are really investing, Hapag-Lloyd or whoever, they can't get that return on investment.

Researcher: I see, so there are government subsidies just for scientific research projects, but not for the containers themselves, yes. I'm slowly realizing now that there are companies in Europe, (like) in China, that give to universities for research and innovation, so the articles published online are pretty much the same as in China. Okay, thank you, thank you for your comments, I understand your thoughts very well, I have no other questions, thank you Professor Zhou for accepting my interview today.

Interviewee 3, December 19th, 2023. Zoom Call, preferred language – English

Researcher:
Before we begin the questions, of course, I'm very much want to thank you for your support for this research. And if you can say a little bit for the official part, how many years you are in the industry? And what is your background?

Interviewee 3:
I have been working at the shipping industry for more than 20 years.
At the beginning 10 years I was doing the job for business related divisions and in recent years I have been working at the digital shipping area for business process and system. And in recent three years I'm more focused on the new technology application. Yeah, like IoT and the blockchain, yes.

Researcher:
So, (Interviewee 3, Name), back to the questions. What is the company's approach to digitalisation of containers. How do you digitise? Which containers do you digitise? What is your company's approach to this?

Interviewee 3:
Actually I'm working for (Name) shipping line, and we have a subsidiary company (Name). It is focusing on the telematic container industry providing the hardware device, including installing as well as the data platform to make the container intelligent. Yeah, we provide the end-to-end solution.
For (Name) shipping line there are some other container lines included into the group.

The container digitalisation - I mean the IoT device, and the application at the platform to utilise the IT data as well as the shipping data together serve the shipping

lines, internal users as well as the externals of the shipping lines, like the cargo owners, the forwarders.

Researcher:
Can you please define out of the scope of use cases main use case for smart container?

Interviewee 3:
Yeah, actually taking the refer container as the example, you know before the container was intelligent, the shipping lines and the cargo owners did not have the internal information about the temperature control, the humidity control, as well as the reefer machine status.
Usually they have to go to the container side to download the reefer logger report if there is any damage happened to the cargo or anything occurred, any exception occurred. Yes, that's the refer container service to the specific cargo owner. It's not good, it's not so qualified as the general container because there is much more data and the information required for that specific industry.
And also for the container alliance, besides managing the container eyesight, they have also maintained the health of the reefer machine because of lack of the reefer status information in time, the shipping lines are always facing the challenge and there's a problem to manage the refer container eyesight as well as the refer machine.
But with this IoT device installed on the refer containers. The information collection is very time consuming, and it (IoT) can help to improve the information transparency to both the internal users and the external users of the shipping lines and improve the operation efficiency. Especially minded the reefer container asset globally. Together

with the position you know real time position of the container.
And you know, usually the cargo at the refer container usually is more valuable. Yeah, with a high value, because most of the cargo is temperature sensitive. Then I think generally, globally such kind of IoT technology helped a lot on improving the transportation quality, you know from end to end together with the transparent transparency.

Researcher:
What is external user? Who is external user usually?

Interviewee 3:
When we see the internal users and the external users understanding the position of myself, you know I am the one of the staff at the shipping line. The “internal users” means that generally those are my colleagues in the shipping line.
“External users” are our customers, you know including the beneficial cargo owners or the freight forwarder. They provide the shipping service from our company and give us the cargo for transportation.

Researcher:
You know, we shared this story about the Hapag Lloyd full fleet digitisation, and they started in 2019 with a reefer and then within the two years was dry container digitalisation.
What is your approach towards this German move of full fleet digitization?

Interviewee 3:

You know, I think HLAG (Hapag Lloyd) is going very fast in shipping line industry in comparison to other container transportation companies.
As we know, for example Maersk- they have achieved of 100% ratio of reefer containers almost five years ago, but they didn't do more dry containers. Well, for COSCO shipping- they are approved in the 100% of smart containers, maybe next year or in 2025.
Well, for dry containers, we are at the starting point. We provide just much dry service to specific customers as per the customer demand.
At the same time, we are watching the market response, especially the customer demand direction to see how much ratio we need to cover for smart dry.
You know to decide and calculate the ratio is very hard because without the data supporting the decision is not smart or intelligent but if we want to achieve a data informed decision, we must have the device on the container.
That is, is hard to say. You know, at the struggling phase, but we all think that to make the containers intelligent, and smart should be the direction of the shipping digitalisation.

Researcher:
Do you believe that for technology going forward or success going forward, you need full fleet digitalisation or this so-called fleet within the fleet when you have a regular fleet and within the regular fleet you have a group that it's a smart fleet. What is your approach?

Interviewee 3:

Yeah. If we the financial issue outside of the discussion, I think it's standardisation is still a problem here at the industry.
Also the compliance.
Problem for many countries.
Because you know, IoT is also a kind of communication technology combined into the device. Yeah, we all know, yeah, there is communication.
Component inside of the device while the communication is a very complicated topic in the world and the container body is a kind of a standard. It's a kind of a product that following the ISO standards; we always see that the container manufacturing with a strict standard as well as the transportation is being regulated by the international standards. Thus, if we install a smart device onto the container sometimes it will cause some compliance problems in some countries. That's how to see an issue and unknown problem. We do not know at what level it is. A kind of a barrier to make the container digitalized and smart. I think that's one of the reasons that most of the shipping companies are watching and waiting.

Researcher:
And if you, I mean now I little bit confused because you have two heads you have (Name) Shipping Line and (Name) Technology Company maybe you can try to answer with two heads. Which technology does make container smart? Was it also RFID tag or only IoT devices?

Interviewee 3:
Oh, I think if we are talking about the technologies that we utilise, we are utilising for smart containers.
I mean the industry, in the past years at, I think at the Early years maybe around 2018

RFID….
was one of the potential technologies that was discussed at that time, including
COSCO shipping and the Box Plus and some other players at the industry.
I heard that even in China, we found it's very hard to utilise the RFID because it
requires a lot of RFID readers to be installed.
At everywhere, you know, maybe at the terminal, at the container depot and so on.
But you know the terminals and the depots are belonging to different parties.
Do you know it is a very complicated relationship. The terminals are invested by
Other financial organisations, the depots, although they are service provider to the
shipping lines, but they belong to other entities too. Then finally if we go to the
shipping lines area, we found that only the IoT device can be self-controlled by the
shipping lines because the IoT device itself can collect the data and report the data to the end
users by itself.
Reduce the dependency to other infrastructures that maybe have to be approved to be
invested by other organisations.
Then here comes 2023. We found that almost all the shipping lines have taken IoT
Technology to make their reefer containers smart well after I think as a kind of technology, it
still has its own scenario, like at the warehouse. Yeah, I think RFID is
still working very well. Yeah.

Researcher:
And again, this is a question for you as (Name) Shipping Line and the (Name) Technology
Company separately.
Which type of providers for technology, you would prefer? what is their origin? Can it
be from all over the world, or should it be only made in China and as a (Name) Technology
Company,
when you buy components to assemble your devices, your technology, who are your

components providers? coming from which country? So, to say do you have any kind of preference?

Interviewee 3:

I think it's a pathway of this, the telematic container device manufacturing in this industry is very similar. I think almost thinking the same criteria. One is the quality of the component.

Then is the availability of the component. Then most important is the cost of the component.

For (Name) Technology Company, as the device provider, we are doing the global sourcing.

Yeah, it is a kind of a global supply chain, like a mining, other IoT suppliers and for manufacturing, we did some research and even in China we did research to select our manufacturing site. Finally, we selected the manufacturer's nearby Shanghai.

Not purely because of the location.

But how to consider the facility?! Make it easy for management. Yeah, we must measure the quality of the manufacturing. Uh, to do the monitoring of the regulatory the compliance and so on. If the manufacturing is in overseas, then it means that we have to do a lot of travel and not easy for communication and to do this on-site check and the monitoring that's finally we selected the manufacturing factors.

Nearby Shanghai: I think the approach, the pathway for such kind of decision is very similar in the in the industry. Quality and cost and how to say availability as well as the complexity of the management and control, yeah.

Researcher:

Was it easier during COVID that your production was close to you?

Interviewee 3:

Pandemic during the past three years, the manufacturing was continuing.

Never interrupted.

Researcher:
It was easy that you can control it in China that it's this is close to you, isn’t it?

Interviewee 3:
Oh yeah, I think it's a supply chain is very it's very successful in the past two years. Yeah, it approved that our initial decision was very smart, you know, yeah, the selection and the decision proved to be correct. You know, even during the challenging times. Yeah. In 2020 and 2021, even in 2022, our manufacturing is continued without in interpretation and the supply of the (Brand name) device, no matter is for COSCO shipping or for other shipping lines.

Researcher:
And from COSCO point of view, if BoxPlus wouldn't exist, would COSCO, still open a Chinese provider or they could buy something from Europe, for example, or for another from another country?

Interviewee 3:
Yeah, actually, you know, COSCO shipping is very open, yeah, before Box Plus was founded, COSCO Shipping Post, COSCO Shipping and OOCL have done a lot of trial run using other IoT devices. And also, COSCO Shipping sponsored. It's how to say R&D project with Shanghai Maritime University for more than 10 years.
Then finally, there is a stop - the BoxPlus I think.
It came from the rich study at the market and at the industry, it is not to self-decided but become from the practice and a lot of trial run and so on. You know the trial run is very open for China device and open for overseas international devices.

Researcher:
But from communication point of view, the data server must be in China, should not it?

Interviewee 3:
Oh, I think it's a data privacy and the data privacy Protection rule is becoming similar and the similar. Even in the USA they have some restrictions and limitation of the data service provider. Well, in China we can use both overseas cloud and the cloud in China. It depends on the business scenario.
If the business purely naturally is international, definitely we can use the international cloud as the container shipping line. Yeah, the business naturally is international.

Researcher:
And for the GSM connectivity, should it be a local Chinese provider or can be any?

Interviewee 3:
No, no limitation. No limitation. Yeah, for us, we selected. It's a global roaming. You know, global roaming connectivity provider. Yeah. What of AT&T? Are China Unicorn. All of them are OK, are fine. Yeah, I think maybe at this level, China is also very open, actually. Yeah. Yeah. We are using the cloud of Microsoft.

Researcher:
Then when you say you speak about the data privacy, how do you experience the use of data that comes from IoT enabled container?
I have an understanding when you said that the data is used internally for COSCO, for the internal stakeholders and also externally for the clients, all types of clients and partners.

Can you please specify again, how you use this data?

Interviewee 3:

Oh, I think you are correct. There are a lot of stakeholders, different types. Yeah, just a different language. You know, I usually call the internal users outside “the users”, but it's true if we think that the staff of shipping lines or the cargo staff at cargo owner companies are the “internal users”, yeah.

Well, I think the logic is very simple. You know for Box Plus it's very simple. Data belongs to the end user. I mean who invested who purchased the ibox from BoxPlus, he owns the data from Box Plus. Box Plus never controls or occupies the data. The data always belongs to Ibox customers. I mean the container owners or the shipping lines, or some logistics the service providers.

That's Ibox customers, then.

When the Ibox customers invested into the Ibox they collect the data and started the data at their cloud server. Then they can utilise the data and can band the IoT data together with their production like business data together to serve their customers, then at a different tier, there's a different rule.

Yeah, for us, as the IoT service provider, you know it mostly related to the business model. Yeah, some hardware providers only provide the hardware device to the end user. Then once the device is installed on the container, nothing happens again. Yeah, only the device sold to the end user. Well, for us, we are providing the end-to-end solution including both the hardware device as well as the data application product to our end users. It is a kind of plug-and-play business model that's very important for as us- to clarify.

The business model as well.
The data ownership is regulated at the commercial contract between us and the our customers.
Well, between the shipping lines and the cargo owners is a different story. Yeah, it is following the industry practice.

I think no matter what type the entity is sharing data always basing on the authorisation, I mean the data owners authorisation is very important. It makes the entity always accomplished with the regulation, no matter the entity is a shipping line or IoT provider. Yeah. For as the IoT Provider, we never share information or data to any party without the authorization from our customers.
Even it is from the how to see Regulatory Organisations. I think for the supervising organisation that even on behalf of the government they should go to the correct party to get the data, yeah.
The logic at the chain is very clear and the simple.
Except sometimes, maybe some organisation they want to make some more financial benefit from selling the data. Yeah, but here I think, for us our (Name) shipping line, yeah, we are very careful to follow the compliance rules even for yeah, if I'm the role at (Name) shipping line when we need to share some data to a third party, the letter of agreement from the customer is always required.

Researcher:
I understand, it's important. But I mean it's so complicated. If you have worldwide, you know, the customs of worldwide, right, you need to make so many agreements.

Interviewee 3:

Yeah, yeah. Yeah, yeah, yeah. It's complicated but the principle is very simple globally, same standard. And the same rule. And we have a global network. And in each area, we have the local sales and account manager for each customer, then the communication channel. And the procedure is very simple, and the customers buy in such kind of a principle because they are protecting their interest.

Researcher:

Thank you, and again this is a question for you as (Name) shipping line and for you, as the (Name) technology company: which standardisation bodies do you join or as a member participate globally?

Interviewee 3:

Yeah, I think globally.

We are now following and participating the ISO standards as well as the UNCEFACT, because you know they are true international and global.

Yeah, for ISO, I think if I'm not correct, please feel free to correct me. For ISO, I think it's more focusing on, the how to say, the quality.

Of a kind of physical product.

Well, for UNCEFACT is more focusing on the electronic interaction of data model.

Yeah, the data component definition, yeah, because there how to add their mission.

The mission of UNECE/CEFACT is to facilitate the international trade. Yeah, the electronic trade to facilitate that's a global trade.

(Name) Shipping Line is a global shipping line.

The shipping is always supporting and serving the international trace you know, without trade, without shipping.

At the (Name) Shipping Line, we have been practicing at the UNCEFACT standards. You know when it's the EDI for more than 20 years, mainly serving our global customers.

Researcher:
Is it true, you need to be a member of the Chinese national association for Standards, right? The local national standardisation body. You are part of the Chinese delegation, aren't you?

Interviewee 3:
I think in China there are several secretaries, secretaries of the international standard body.

We have the ISO TC-104 Secretary in China, on behalf of Chinese delegation. Yeah. I'm one of the how to say the expert of the ISO TC 104, registered by that secretary.

Yeah, and, you know, the UN ECE/CEFACT may be following the same architecture and organising structure because you know they have also countries delegation.

I'm not at the expert of the procedure too, you know.

I required it for joining UNCEFACT- based on your advisement, do you remember?

Yeah. When we did the job for the safety device. You'll suggest to me to join the Smart Container project as well as the cross-industry track and the trace.
Then I went to the UNCEFACT secretary to require joining. I mentioned that these two projects, then they let me fill in a kind of a form and then maybe some weeks later I was informed by the UNCEFACT portal that I'm an expert and I can select a project to join.

Researcher:
What is the interest of Chinese national standardisation bodies in this type of technology and this part of the industry? is there a national interest in standardisation?

Interviewee 3:
Actually, I think China is trying to do some standardisation for the variable industries. Because, you know, China is very big and the industry is, how to say, we speak about many industries, the chain is very long and yeah variable.

Some organisations on behalf of the industry like I have a logistics association or an organisation on behalf of logistics companies or on behalf of the shipping companies. Somehow, I think it may be similar even in in Europe or America, there's some industry associations and they create some standards for their industry. Yeah. And also, we have the transportation, you know.

Transportation industry and also, we have the container, we have technical committee. Committee National Technical Committee for Container Manufacturing Industry.

Researcher:
So, what is their interest, that it will be harmonised with the global standards or first standardised within China and among the Chinese device manufacturers?

Interviewee 3:
I think the basic principle is almost the same. You know, whenever there's a new standard created. Yeah, it must be aligned with the exist standards. Yeah, that's the first one principle. And also, I think in China there are many standards which are translated from the ISO standards or UNCEFACT standards, accepted from the ISO or

the UN CEFACT; then transformed into national standards, but it is still international, then all the new standards are coming. It should be aligned with the national standards first. Then it means it is aligned with the international standards. Then the main body is ISO, IEC and the UNCEFACT, and maybe also ITU.

Yeah. So that is a communication. Yeah. Yeah, yeah, yeah, yeah. Yeah. All the all of them are from the main international bodies. Yeah. Yeah, yeah. Yeah.

Researcher:

Are the digitalisation efforts subsidised by the government or not?

Interviewee 3:

I think it is really a kind of a complicated topic. How to answer actually, you know, in China the daily life, I mean for people, you know, the daily life is really have been I think, digitalized. You know the mobile phone. If you take a mobile phone, you can go anywhere.

No intent to use the wallet, wallet, you know.

Because of one mobile phone you can do everything, pay a booking or anything. I do not know how this has been achieved. I think maybe because you know the direction from the policy.

In IoT case, no, no, no, no, no, no, no, no, no, no, no, no, no money from a government. You know also money is a self, how to say self-born by the company.

Yeah. Yeah. It's a very frankly speaking. Yeah, maybe at the policy level. Yeah, if

there's an entity, which requires some loan from the bank, maybe if their industry is innovation or digital or something else very interesting, maybe they can have a good maybe loan, but I'm not sure. I don't know. I don't know. But yeah, yeah, yeah, but frankly speaking, for us (Name technology company), never get any loan, no money from the government.

It's purely commercial. Yeah. Yeah, yeah, yeah, yeah. Yeah. 100% of marketing. Yeah. Yeah, yeah, yeah.

Researcher:
This is fantastic because if you read academic sources and also in Chinese, it's written that this, the Made in China 2025 policy, it's kind of motivation for the whole industry and you can read it that so much money was put into factories and production. And when I speak to business, business must strive to survive as well.

Interviewee 3:
But you know, really very interesting that like I said that I don't know how it happened, but it's really, it's really happening, you know, everywhere in China is being digitalised.

You know, even our daily life is being digitalized, being digitalized when we require. But I think all over the world is being digitalized and adjusted, the pace is different. You know some country is going faster, some country is at the starting point, yeah.

Researcher:
Thank you for your time!

Interviewee 4, July 24th, 2024. Answers were forwarded in written form, preferred language – Chinese (English Transcription). Questions were requested ahead of the interview call

Interviewee 4: Below is my personal professional understanding of container digitalization, which does not represent the views of any company:

On the Trend of Smart Containers:

1. **What is your company's approach to container digitalization?**

1. **Deployment of Smart Devices:**

This primarily involves the use of sensors, control modules, and smart devices to monitor the container's status in real time. These sensors and smart devices ensure the accuracy and timeliness of the data, laying the foundation for subsequent digitalized management.

2. **Data Collection and Transmission:**

Using IoT technology, the data collected by the sensors is transmitted to a digital platform or cloud server, providing users with real-time container data.

3. **Data Analysis and Mining:**

Based on the collected data, big data and cloud computing technologies are used for analysis, enabling the creation of predictive models, warning mechanisms, and more. This improves transportation efficiency and provides reference points for customer decision-making.

2. **For you, what are the primary use cases for "smart" containers?**

Real-time visibility and monitoring of the following: container location and status, internal temperature, humidity, cargo within the container, cargo owners, loading/unloading processes, shipping and delivery, door activity (opening/closing), and maintenance. These features enhance cargo transportation safety and improve operational efficiency.

3. **What is your opinion on Germany's approach of making every container traceable through IoT devices?**

Against the backdrop of global logistics upgrading, the logistics industry is gradually advancing towards digitalization and intelligence. Germany's initiative to make every container traceable through IoT devices is an important step in this transformation process and holds positive significance.

Firstly, IoT devices significantly enhance the transparency and efficiency of container transportation. By providing real-time feedback on container location, status, and other data, customers can more accurately grasp transportation conditions and adjust their logistics plans promptly.

Secondly, the application of IoT devices improves the safety of cargo transportation. Any abnormal changes during container transportation can be detected and handled in a timely manner, effectively ensuring the safety of the goods.

Lastly, Germany's approach of making every container traceable through IoT devices serves as a model for other countries. It inspires more nations and enterprises to focus on and promote the digital transformation of the logistics industry, further advancing the application and development of IoT technology in the logistics field.

On Technology:

4. **What technologies do you use to digitalize containers, such as IoT devices, RFID tags, etc., and why?**

Our company is solely a container manufacturer, so we are only involved in the installation of smart devices and have no deeper understanding of this area. However, I believe the choice of technology primarily depends on factors such as user requirements and functionality, equipment purchase and installation costs, operational costs, and supporting facilities at related terminals and storage yards.

5. **Apart from the technology providers you currently use, which other providers would you consider, and why? Do you have any preference regarding the country of origin, such as China, Taiwan, the US, or Europe? Why?**

Our company is solely a container manufacturer, so we are only involved in the installation of smart devices and have no deeper understanding of this area. However, I believe that an open attitude should be maintained toward technology providers. As long as the technology meets

functional requirements and offers high cost-effectiveness, there should be no restrictions on whether the provider is domestic or international. Currently, these technologies are relatively mature, and the differences between domestic and international technologies are minimal.

On Data:

6. **How do you use the data collected by "smart" containers?**

Our company is solely a container manufacturer and does not handle data collection.

7. **Does your organization plan to share data with freight forwarders, port authorities, or beneficial cargo owners?**

Our company is solely a container manufacturer and does not handle data collection or sharing. However, as far as I know, different shipping companies use their own data collection platforms and currently have no plans to share data with each other.

On Standardization:

8. **Which standardization organizations do you and your company participate in, and why?**

We participate in the international ISO TC104 and China's container standardization organizations, primarily to contribute to and promote the development of relevant standards.

9. **What are the main technological interests of the national committees?**

Advancing national scientific and technological progress, industrial upgrading, smart cities, and environmental protection.

10. **To what extent, in your view, has digitalisation been subsidized by the government?**

I am not familiar with this area. However, I believe that container digitalisation cannot rely solely on government subsidies. It is more important to find a suitable business operating model.

Interviewee 5, March 15th, 2024. Zoom Call, preferred language – Chinese (English Transcription)

Researcher: How is everyone? Thank you, thank you for taking the time to come.

Interviewee 5: It's like this, it's no problem, I am very happy, I mean, I will answer some questions related to Chinese port containers. I think our thoughts are basically aligned.

Researcher: Good, yes.

Interviewee 5: Okay, should I answer according to your questions, or should we do this in a conversational way?

Researcher: Okay, then we will follow the questions, and Professor (Name), if you have anything to add, you can say it at any time, okay? Thank you, because your time is also very precious, you are very busy.

Interviewee 5: Okay. Secondly, there is no problem in having a longer exchange. It's 7:10 PM here in China now, no problem.

Researcher: Okay, thank you.

Interviewee 5: I'll still answer according to the questions, okay? The first question is about your company's approach to container digitalization. Is that what it means? Okay. Secondly, I am now, of course, at the Logistics Institute of (Name) University, mainly engaged in work related to port logistics. Recently, in recent years, research on smart port logistics has become a popular topic. I always feel that port digitalization is an inevitable trend. Traditional container or logistics are actually based on physical elements. The information connections between them are mainly through emails, so it is written on them, doing all of this in electronic form. In the

future, with the development of IoT, the big trend is definitely towards digital operations. For ports, previously and now, there are a few hot topics attached to digitalisation, one of which is about container automation.

My enterprise is (Name) Port. (Name) Port has maintained a leading position in container transport recently. Last year, (Name) Port's containers reached 49 million TEUs, and this year it is expected to reach 50 million, possibly the largest ever in history. In this aspect, the work on port digitalisation includes establishing systems for the entire container loading process.

Researcher: So, currently, it's about automation, right?

Interviewee 5: Yes, in China, automated terminals are new, and old ones are being upgraded. Digitalization covers all aspects, including loading and unloading. From shipping to automatic cranes unloading containers to automated moving them to container yards, the entire process is automated. This system aligns with automation, increasingly incorporating AI for better management and optimization. Ports are heading towards comprehensive digitalization.

China's major ports are doing this, and other ports are following. I estimate there are 8 to 10 fully automated ports in China, with more in development. Automation is seen as a direction for growth, and digitalization is a future trend. Shanghai Port exemplifies this with three main levels of design: using internet technology for monitoring and tracking, ensuring safety and transparency through sensors and GPS. Another level involves cloud computing for efficient data storage and sharing, enabling effective data analysis, modelling, prediction, and early warning, enhancing port efficiency. AI is also being used to further develop these technologies.

On another level, Chinese containers are being digitally upgraded. We've established a Chinese standard for container QR codes, issued by a container bureau in France. These QR codes enhance container digital capabilities and prevent tampering. This transition to digital systems, including Bluetooth integration, is a trend replacing older methods.

Regarding container digitalization, the process is underway in China, with trends moving towards using new technologies to replace simple numbering. NFC installation is costlier, but QR codes are cheaper and highly efficient. The digitalization includes secure management,

network and logistics data protection, a crucial part of the digital framework. China's containers are progressing in three major areas: digitalizing the containers themselves, establishing responsibility and customs supervision using digital seals, and further advancements in container digital monitoring and management.

For example, digital seals are widely used in China for logistics responsibility. They are quickly adopted in various logistics companies. Containers equipped with these seals can be tracked and verified upon delivery. This method is increasingly adopted in secure and expensive logistics like tankers transporting fuel, ensuring security and accountability.

Additionally, there's a growing use of digital locks for integrated customs clearance and monitoring. These locks connect to large data platforms, providing comprehensive logistics information. The latest development includes integrated container monitoring terminals and sensors for real-time environmental data, crucial for secure and efficient logistics operations.

However, widespread adoption is gradual due to costs and technology readiness. It is more common in valuable shipments. Shenzhen leads in these technologies, with several companies developing advanced monitoring systems, ensuring safety and responsibility.

Monitoring technology, especially for valuable goods, is crucial. For instance, GPS tracking in smart containers allows real-time updates on temperature, humidity, and movement. Although satellite communication still faces challenges, especially in areas without signal, China is progressing with these technologies. Currently, about 200,000 containers are equipped with QR codes, enhancing identification and tracking. These advancements in smart containers hold great potential for future logistics efficiency and security.

Regarding supplier preferences, China remains open to products from any country, provided they meet cost and efficiency criteria. For instance, Apple products and other international goods are widely used in China, reflecting this openness.

China actively participates in international standardization efforts, including ISO and national standards. The goal is to integrate advanced digital and AI technologies into these standards, fostering industry growth. International collaboration in standardisation is essential, as container logistics is inherently global. China aims to contribute to these standards, promoting global compatibility and efficiency.

Government support for digital logistics technologies comes through research projects rather than direct funding. This approach supports technological advancements while encouraging industry adoption through project-based funding.

Researcher: So, you believe that digitization is the future direction, and Germany might be a step ahead, right?

Interviewee 5: Yes, the technology is well-developed. I believe Germany might progress faster due to their advanced industrial and electronic technology. Tracking and monitoring each container are an inevitable trend.

Researcher: I see. Thank you. Now, regarding suppliers, do you have any preferences for Chinese, Taiwanese, American, or European products? What factors do you consider, like technology?

Interviewee 5: Our approach is open. We use products based on their reliability and suitability, regardless of origin. For example, many in China use Apple products, and our bags from Germany. What matters is the product's reliability and effectiveness.

Researcher: So, price is a significant factor?

Interviewee 5: Yes, price is important. Reliable technology is crucial because monitoring devices should ensure data transmission and safety. For instance, we tested devices from Shanghai to Yunnan, ensuring consistent data transmission.

Researcher: You mentioned standards. What standards organizations does China participate in, and why?

Interviewee 5: China participates in national, industry, and enterprise standards, with ISO being the most prominent. National standards are overseen by the National Standards Committee (SAC), and container standards are managed by the Ministry of Transport's Standardization Committee. China actively engages in ISO standards to promote advanced digital and AI technologies, fostering industry development.

Researcher: Does China participate in IMO standards?

Interviewee 5: The Ministry of Transport participates in IMO standards related to maritime regulations. Containers fall under the jurisdiction of the National Container Standardization Committee. China aims to contribute to international standards, ensuring global compatibility and efficiency.

Researcher: What about government subsidies for digital logistics technologies?

Interviewee 5: Government support comes through research projects rather than direct funding. This approach encourages technological advancements while supporting industry adoption through project-based funding. The focus is on innovative projects rather than commercialized products.

Researcher: Thank you for your insights, Professor (Name). This has been very informative.

Interviewee 5: You're welcome. It's been a pleasure discussing these important topics with you.

Researcher: Could you tell us about your personal experiences and achievements in the field of port logistics?

Interviewee 5: Sure. Over the years, I have been involved in various projects and initiatives aimed at enhancing port logistics efficiency. One notable project was the implementation of an automated container handling system at Shanghai Port. This project significantly improved the port's capacity and operational efficiency. Additionally, I have worked on integrating AI and big data analytics into port operations to optimize container tracking and reduce turnaround times.

Researcher: That's impressive. How do you see the future of smart ports and digital logistics?

Interviewee 5: The future of smart ports and digital logistics is promising. With the continuous advancement of technology, we can expect further integration of IoT, AI, and blockchain into logistics processes. These technologies will enhance real-time tracking, improve security, and enable more efficient resource allocation. The goal is to create a fully interconnected and transparent supply chain that benefits all stakeholders.

Researcher: What challenges do you foresee in achieving this vision?

Interviewee 5: One of the main challenges is the high cost of implementing advanced technologies. Additionally, there is a need for standardised protocols and regulations to ensure compatibility and security across different systems Collaboration among international stakeholders is crucial to address these challenges and drive the industry forward.

Researcher: Thank you again, Professor (Name), for your valuable insights. This has been a highly informative discussion.

Interviewee 5: Thank you. It was my pleasure to share my experiences and thoughts on these important topics.

Recording Interviewee 6, June 10th, 2024. Zoom Call, preferred language – English

Interviewee 6:
So you're taking a PhD on IoT, I guess Yes, yes.

Researcher:
And so it's very, it's honestly very interesting topic because I'm trying to understand what Chinese approach towards the smart container is.
Now I would like to understand also your opinion from all the experience.
I will ask you concrete questions.

I will not disclose your name, title, position and everything as I see from the letter of consent, I would still ask you in the beginning, can you give me a little bit of introduction to your background?

Interviewee 6:
OK, I come in touch with IoT when I was working with APR the so I was with APR for 11 years and in fact not even before that I was reviewed very fast for I was assigned to be part of the TC104 committee and that times was in year two year 1999.
There was quite some time back where we start to look at the RFID on the custom seal.

There was quite some time back at that time, so PSA is trying to lobby the RFID seals, but I think it was not very successful during that time.

Then when I joined APL, we continued to look at RFID seals, we continue to look at containers using tracking device.

By that times was actually everyone was not focusing on that particular site activities because they find that this first is too costly during that time.

At the same time, also in general right now the shipping the way containers and cargo been tracked quite it's very little intensive, but there's really a standard process in place.

So, then they decided to, you know, stop and don't talk about IoT until I think in 2005, I think it's in 2005 where CIMC come up with this smart container.
So at that times I, I was thinking that we, we did talk to CIMC why they want to develop these smart containers and that initiatives was driven by the local government.
All right, is because of the Belt-and- Road initiative.
And then I noticed that if you follow the progress is they have been doing a lot of trial with the seal activities on the on, on the roads or activities to track about containers and so on.

And I guess for my past background is I have been involved in this here and there in terms of understanding what is going on with the IoT, the tracking device and, and things just move on.
So, so back then that's my, that's, that's where my background was involved in IoT.

Researcher:

Yeah, we will speak also from the, your view of today because you, you now sit on the other side.

So, you can, you can answer me from the position of today.
What is your company's approach to digitalization of containers today?

Interviewee 6:
I think today's IoT device much affordable and I think the shipping lines have actually realized that today the container have grown to the certain size and it's difficult to manage without tracking them.
And in the past records over my past experience with the shipping lines is we encounter a lot of container loss, you know missing someone categorize the containers, we don't know who

use it and also the container was used for smuggling or doing a lot of so-called illegals activities.
So I look at IoT come at a right time where it does help the shipping lines to get throughout the I set in tech and because these are real time, they can track, they can understand that OK, where are their containers all the time.

So it helped them to be able to manage their fleet optimizations in terms of security, in terms of cargo management.
All these things are very much easier for them to manage based on if you have a IoT tracking device in the past, it's like they don't have this and we maybe the fixed size is not growing to a certain, you know, a size.
But now today we're talking about in the market, you're talking about probably 38 to 40 millions of containers, 40 in the in either global, globally.

So where are they today, if you ask the shipping lines, most of them do not know.

Researcher:
You heard about the Hapag Lloyd deal, right?

But this kind of approach of Hapag Lloyd to go full fleet, right.
I haven't seen after that any shipping line to go full fleet.
What is your opinion on German approach to have each and every container trackable?

Interviewee 6:
I think it's for shipping lines.
For my participation from shipping lines.

Researcher:
Is there a different way of looking at the tracking device?

Interviewee 6:
Some of them we'll look at is use tracking device to only track cargo, not container.
So if you, if you aware that all the reefer containers that must I have, they have these RMM plus that they track all the refer the temperatures, the performer, the machines because there's small so-called liability issue.
So for reefer I, I will say that most of the shipping lines today will have a tracking device to track the performer of machine and at the same time also tracking of the cargo temperature.

So that is because reefer cargo are more expensive and machine breakdowns will damage the cargo.
So the likely that there's a way that a way to 1st to determine whether is there any risk if I don't use a IoT today?
So there's I think for shipping line's perspective is the same.
Is there any way that I don't use IoT?
If I use IoT, what is the value that I'm gonna get right.

So I think in fact, if you look at it, Hapag Lloyd have moved.

Hapag is always the one that is very much into technology innovations.
And if you look at our fixed size, they are very much more diversified than the rest of the shipping line.
They have a lot of different special equipment, whereas the rest of spring lines are very conservative.
They just manage a very standard fleet, either refer or standard containers.
They hardly have a lot of special equipment.
So there's a very different way of shipping lines looking at different kind of products.

So I will say that if Hapag Lloyd managed to use the device and proven that they can optimize their fleet and able to prove that there's a significance or way of reducing the cargo

claim or reducing empty repo cost.
If they can prove that the device are able to help them on that purpose, then people will the rest of the streamline will then adopt.
If it's purely for cargo, I thought they will install IoT device on the container.

Researcher:
So, sorry if just to recap, it's basically shipping lines will look at more about cargo reliability first, not on the container.

Interviewee 6:
So the containers has been it is always a secondary for the shipping lines to consider because container are not so-called a asset to a shipping line.
For shipping lines, their main asset is lesser.
So in most of the shipping lines, the container is always a support role.
So they don't pay very much that expense to container.

So what I'm trying to say here is unless the IoT device that put on the containers had added significant value, then they will switch.

Researcher:
It's it's very interesting.
I'm, I'm telling you kind of off the record because all the IoT companies that are approaching shipping lines and leasing companies like Florence, they are trying to say that IoT helps to utilize better the containers.
Therefore the basic IoT package has track-and-trace for dry containers, especially reefer case is absolutely obvious, right.
But for track container fleet, they say track-and-trace and cargo sensors on the on demand because it's also hard technology wise.
And this narrative doesn't stick.
Only Hapag agreed to this kind of right.

Interviewee 6:
Exactly.

Researcher
It's very interesting and they're continuously doing it more than 10 years, right.
This is the same narrative all the time.
Do you know where's your container that you want to utilize it better because it doesn't move during the year too much.
If you think about Chinese containers, I mean, we speak about wholesale and COSCO basically, right.

Interviewee 6:
We don't have other Chinese containers.

Researcher
What would it be your opinion?
Which technology would they use in order to digitize the fleet?
Would it be again the RFID seals or RFID tags?
Or they will move now with this box plus company into IoT?
How do you feel?

Interviewee 6:
my feeling is they will they almost to box plus IoT.

The reason is because China's are transforming themselves into a more of a high-tech country.
In fact, if you look, if you hear the news, always the even he chairman of the country will always mention that we they want to grow the next 30 years is for about high tech, about high technology.
So if you realize that today in China's EV car is like flooded in the whole China, if you've been to China today, you can see that on the road almost like 30 to 40 percents are EV car.

So in in the port in the in the back to the container site in the port area, they are they are in the midst of transform, transforming the port into a virtual port.
And today there are quite a number of virtual port in China major one like the Yangshan, Yangshan terminal, the Qingdao terminal, right, and Yanjian terminal.

So those are ports that they are slowly transforming it into virtual terminal like what we have in Singapore.
So they are also use a lot of those, oh, I called it, they're the EV, they call it what the EV truck.
So inside the inside the terminal.
So what they what they're trying to do is to integrate all this high technology into one platform where they can track truck, the crane operations, the container operations inside the port.
So if they could do that, it means that they are able to capture all the activities real time.
Do you think that sorry, the other thing is I noticed that what they are doing this for is also to one of area that I can foresee is going to happen is also for security reason and is also for custom clearance reason.
So they are able to track all the cargo in out of the terminal.

Researcher:
Do you think that for this purpose, the technology that Chinese will consider will be of multiple providers or would they have any preference related to the country of a region like for example, made in China or do you think they can go made in Europe and so made in Taiwan?

Interviewee 6:
I think for what I understand so far, they have no restriction to say that they only use a Chinese tracking device.
They can use anyone, any, any tracking device so long as meet their standard of reform.
And yeah, but they themselves are very strong into this tracking device technology.
As you know about Huawei, ZTE or another tech, I can't remember.
There are a few number of trackers.

I mean, they call it sensor provider where they are able to track using the 5G.
So they are very much into this so-called.
I, I will say that they, they claim themselves they have a highest advanced technology than the rest of the world, right, In terms of 5G, yes, yeah.
So what, what they are driving for is to use the 5G as a platform to, for all the IoT device.
From what I can see, because today we are all talking about the most is like the tracking device is more about like, like 4G, right even down to 3G.
But they are talking about the high end of the tracking device.

Researcher:
How would they use the data that they collect from the smart from the smart container?
Let's focus exactly on the containers.

[redacted]
Containers I, I believe that because they, they really know, OK, let's say for example, the container, the container itself, the basic information of the containers.
And then they will know whether the container is empty or loaded.
If it's loaded, then there's they will know what kind of cargo is inside there, right?
And they will track like for example, they leave the warehouse to the port or to the railway stations or whatever and they can track the data from point to point until even the destination of the discharge and according back go, go back to the depot empty.
So I believe that if it's the tracking device are on the containers, they know exactly the containers are loaded and not loaded.
And if it's loaded and what kind of cargo out from China, they won't be able to track the rest of the world, but they can track whatever is out from China

Researcher:
So this give them a very strong database to determine that what is the demand out there, right? They will know what kind of demand out there where does this cargo landed with and then why?

And then they can study. they call so-called the data, the information to derive certain kind of so-called what, where are the area they should be focusing on, right.

The other thing is also; do you want to prevent any kind of illegal trading of each activities happening?

Interviewee 6:

Yeah, I think this is very much about security.
I think this is this is also shipping lines.
I'm not sure you're aware that in every shipping line there is a security department, no, OK, there's a security department looking at all the contraband or smuggling or any illegal activities happen on containers.
But this one I think you just know will do because it is a is all the shipping lines they will deploy certain like the custom official?
That work with hand in hand with the with the shipping line and these people are always call themselves as a security team because in the world as you were aware that even in most of the like undeveloped world where they have a lot of smuggle of drugs or whatever, right.

Researcher:

So these are the activities that may have it happened here and there, but then how do they know that it's using whose containers?

Interviewee 6:

So these people are tracking all these illegal activities and then and, and then they will identify where the world or where the where's the source of these activities is happening and so on.
Then they were able to capture them.
So these are the every shipping line have this at if so-called security team that is working together with the UN Security team, this worldwide it happened in every UN, every shipping lines will have this team inside there.

So, this these people will be very much into one thing the IoT device. Yeah, but do you think they are ready the shipping lines forced by these departments of security, will they be ready to share the data with freight forward US or what authorities or beneficial cargo owners?

Researcher:
No, you mean the security team, security team and the shipping line in so container on the shipping line in in general will be they interested to share this data with freight forwarder or cargo owner for example with freight forwarder to update on the delay with cargo owner to update on any damage that's happened in a real time or with port authorities saying we have a suspects, we suspect that there is illicit goods inside.

Will they share it, or will they operate internally and not share it externally?

Interviewee 6:
For security teams, they will not share. Yeah, even for shipping lines, they will not share cargo details with any forwarders because they were they will have they sign a confidential agreement with the shipper.

So normally they will not share.

So, in a manifest or in a bill of lading, usually they put there a general kind of goods, the descriptions they will not share the details about the goods.

So, for security team is because they are tracking illegal activities.

So, they definitely won’t share with the information with anyone even in EV and booking claims regular booking or the kind of how you call it container steering departments.

If they have an IoT on the container and they see that something happens in real time, will they be willing to share the data for example, with a freight forwarder which is assigned to

this shipment to say, look, our container was short seed?!.
Meaning it was not loaded on the vessel and the port of in PoL.

So don't expect it in POD, it's not arriving.

Researcher:
Will they share this information in real time?

Interviewee 6:
They will share to if the if the shipper requests that they want to track their goods from point to point, then they will share with that particular shipper.

Researcher:
But will it be more efficient to when they have the data of IoT device or it doesn't matter They know it also through Adis that container was left behind or anything.

Interviewee 6:
Exactly yes.

Researcher:
So IoT doesn't change here much, right.

Interviewee 6:
No, I, I will say that IoT may become a, a, a let's say for example, right now, because IoT is, is more like a device that provide commercial value, but not so, so much about liability or security requirements.

Researcher:
But if, if we receive security requirements, then it become like it's a enforcement by UN.

Interviewee 6:
If it's enforcement by UN, then we don't need to discuss everything will be, you know, enforced that they need to have.

Researcher:

So, you will know that ISO is trying to set up a standard rules about like IoT must be confirmed to all these standards and requirements.

Interviewee 6:
I'm sure it's like, it's so because I was, I was there before.
So I know that there are certain requirements that they need to make sure that it will not be being “moralised” by any of the entity who uses the device or, and that means that all the IoT device providers are able to participate at the same time and also adopt the certain standards.
I think the, the key area where they face is always a (radio) frequency that they use.

I'm not sure this has been resolved or not.

Researcher:
No, it's not reserved yet.

So this is where I, I was, I was thinking that it's like these are the things that have to be standardized or else it's very difficult to implement IoT.

Researcher:
So even like if this IoT is going to become a requirement that is easily enforced, but if it's only adding, adding on to a commercial value, it's very difficult to push forward from your time in TC104 on the on the Chinese side, which technological interests could you identify on the Chinese side to participate as of no, Like there's a national committee, right?

Interviewee 6:
I don't know if everyone is actively involved in the in the Chinese National Committee for standards, but you could understand the Chinese group or team has particular technological interests when they speak standardisation, for example in ISO TC 104 or everyone pulls their own direction, like Professor Bao forever pulls the RFID seals.

Researcher:
I see.
it is very interesting.
Very important information.
Especially knowing, you have participated so long in the ISO working groups.

Do you do you have any, do you feel any alignment there on the interest on technology?

Interviewee 6:
I think the Chinese want to get their yeah, so-called their standard be part of the ISO standards so that they can influence the rest to follow their standards.

I think it's very I look at it, it's like the Chinese way of do looking at thing is like if I can put my if I develop a device that I always set these standards, if I can use this standard as part of the Internet standard, then I know it to spend a lot of time to do my R&D work.
So to them it's like I as a as a businessman, they will try to find a way to produce their product in a so-called more economical or cheaper way to, to produce their product than not to spend too much on the R&D cost.

So, these are the Chinese, you know way of thinking of producing this.

Researcher
But I understand that for Chinese who develop all this device are all driven behind by the government.
OK, this one is pretty much you can read out all the articles that is behind the scenes.
The government is the one who pushing them to go and make this thing happen.

But do you think that it's also subsidized and the whole digitalization subsidized?
Because I will tell you why I'm asking you this question or they are not willing to say to me or that's really true.

Box Plus said to me, I even don't know what is made in China 2025 and all these digitalization attempts and she said I have a feeling of direction right that we go to digitalization, but we are not sponsored or funded more from the government because we do IoT devices, we don't give subsidies nothing.
And she says even to conferences I can't go in order to learn about what's outside.

Interviewee 6:
OK, exactly.
I can show you that they don't call it a subsidised, but then they have this so-called R&D component in their tax filing.
So, if they can prove that they have developed a new device, or something is new that they can actually quantify this as R&D cost.
It means that this cost can be waived through tax.
They don't get subsidised, but they get a lot of R&D costs with a tax waiver.
So indirectly they get subsidised.

Researcher
I see, I see you see.

Interviewee 6:
It's, it's a question, it's how you ask the question, right?

Because if I am saying do you get the money from the government for this, you said no, I think it's true.

Researcher:
And this is what this Professor Bao from Shanghai Port to me tried to say to me.

Interviewee 6:
He spoke Chinese, right?

Researcher:
So I translated, I mean, we had an interview in Chinese and then I said and tried to translate what he said.
And he said basically the same.
He said if you have an R&D project, you can apply for R&D, right?
But if you are a company that develops technology, you don't have any extra benefits, right?

Interviewee 6:
So it's a how you file it, yes.
So align with what I say.
So this is true that in fact all the Chinese company, they get a lot of tax discount from the government in terms of R&D costs.
That's why they are very much into doing a lot of R&D and then to try to try to palm out their R&D departments.

Let's say for example, I can, I can show you is like for example CIMC, we know that they are

major container manufacturer.
The R&D team itself, it's like 1000 people and they just do container only.
They have their own patent lawyer, about five or six patent lawyers.
They have their it's a huge team.
They're just doing R&D because so paid by the government indirectly.

Researcher:
But OK, we are out of official questions, but I want to understand, OK, yeah, to do extra things when I started with next year eight years ago.
So we have been at Container Owners Association and a guy from who is always coming from CIMC was presenting the idea of a smart container by default build smart container, right?
And he was then showing my device next year device as a competitor.
We still haven't been in the in the in maritime.
We tried something with Maersk, but we have been in trial.
So he showed device, my device and saying this is the device and we will do it already at the factory.
So we will, and they showed some kind of plastic box on the device that this is the new generation of smart container we will produce then disappeared absolutely from all, from all the, and then the discussion behind it.
And what also lays in my research was we will not trust the smart container built in China because the SIM card will be Chinese where who sees my data.
Maybe they will collect my data if I am Hapag Lloyd, right, buy it from CMC directly smart container.
Maybe they will seal my see my data, use it against me.
This was the this was the talk and then it disappeared.
What happened with this department and CMCO of smart containers?
Do they exist?

Interviewee 6:
Yes.

Researcher:
And what do they do?

Interviewee 6:
They do a lot of market research to find out who are their competitors, what are their competitor doing and understand what they are, what kind of device they are using, what are the feature they have and so on.

Then they were internally trying to develop similar kind of things to make sure that their device are more advanced than the rest of the competitors.
This is very stand the way for the peoples, I mean for R&D teams, their job is to go out and find out what is in the market and what they can do to show that their product is more advanced than others.
So they will definitely come and try to talk to you and find out more about, you know, next device.

And so, this is very it's they are just lobbying.
They are not lobbying their products in per SE, but they are trying to find out more what's inside the market.
Outside the market.
Yeah, I knew that very well.
It's 30 years working with them.

Researcher:
Thank you, [redacted]

Interviewee 6:
Thank you so much.

Note:

Few days later, Interviewee 6 sent a message:

Hi Researcher, I was thinking about IoT if your PhD thesis is about the general of IoT devices an essential part of the container? Then it will be best to focus on what is legally binding or Law enforcement by IMO or UN charters on sustainability for instance is CO2 emissions tracking is a must under the UN charter? Is Cargoes security a concern under UN charter. As mentioned, containers are a supporting equipment but not the main asset for shipping lines, shipping lines will focus on container ships meeting CO2 emissions first. Chinese smart containers developed by CIMC or Chinese government wants to turn China into a high-tech country and hence most logistic companies are working toward upgrading their logistic and ports facilities such as fully automation and virtual operations and enable them to operate the activities inside the warehouse and ports more efficient and able custom to track all cross-border cargoes import and exports swiftly in real time. Thus thrive Chinese companies to focus on developing high tech devices like IoT, lidar, robotics, AI, 5G, etc for the country.
Hope this is helpful for your thesis.

Interviewee 7, July 3rd, 2024. Zoom Call. Preferred language - Chinese (English Transcription).

Researcher:

A brief exchange on how this interview will be conducted, and then there's also about that non-disclosure agreement, which we already know that you've signed.

Interviewee 7:

Yes, my understanding, it's a technical issue, we are fine with it, (the information) is all public, hahahaha.

Researcher:

Yes, yes, yes, the main thing is to be able to record and videotape and how it works, that's great, very good, no problem, thank you.

Interviewee 7:

Ah no problem, can.

Researcher:

Shall we do it in English or Chinese? Maybe Chinese is better?

Interviewee 7:

Ah, you can (use) Chinese, Chinese is probably better, (so) it's easier for me to explain to you.

Researcher:

Right.

Interviewee 7:

Because you have audio and video recordings, we can double-check if there's anything in the future.

Researcher:

Ah, that's fine.

Interviewee 7:

I see, I see no problem, that's the best. Yeah, okay, you start.

Researcher:

The first question is: What is the methodology that your company uses for digitizing containers and how did you go about digitizing containers?

Interviewee 7:

Ah, good. I'll answer one by one, okay? It's about the way the container is used in terms of digitalization. I think it has a different stage of development.

Since I came to the Ministry of (Name) to participate in the work of the Academy of Water Transportation Sciences in 2003, ah, has been engaged in container transportation research.

Our centre, now called Logistics Centre, originally called the Container Technology Centre, so that our centre from the beginning to do container technology research. The development of the container ah precisely is experienced from the traditional transport to an intelligent and information-based transport mode of a change. I personally have a simple evaluation of the development stage of container informationisation, that is, in the traditional mode of container transport, more attention is paid to the container. We currently have relevant international standards, such as UN CEFACT, which is a container of electronic data transmission, which (in this regard) the United Nations has a number of relevant message standards, and these international standards, these shipping companies are widely used. This is the first level of digitization of containers. And with our ISO TC 104 counterparts, is that we have a lot of container mode of some of the codes, such as ISO 9897, ISO 9711, these are we believe that the traditional container digital transportation or to the digital transformation, one of the most basic some of the applications and standards, which are necessary in this the industry.

On this basis, and then began, we think it is like a 2.0 or to a higher level of information technology and digitalization of a stage of development. In this stage, we also see some friends, including the United States, including Germany, there are friends in France, then pushed the container electronic tags, that is, ah, some of the applications of RFID we TC104 also formulated the international standards, I remember that there were a few standard number is 18185, and then has been later the total package of Prof (Name), and they have been ca. 286, and there have been far later, our friends in the United States, and Lars Kjaer, and Worls Shipping Council, and the United States of America. Our American friends and Lars, they proposed 18625.

Researcher:

Yes.

Interviewee 7:

This is all what we consider to be the second stage of container transformation to digitaliszation or informationisation. We in China domestic, we put the original call (to address) for a simple

information technology management, and then to this second stage is more focused on the Internet of Things and big data an application, which is what we are currently doing in the industry.

In fact, about the electronic label QR code tag, including the application of satellite positioning sensors, we are from the digital point of view, hmm, categorised in the second layer, but also the industry is currently accelerating the promotion and application of the level. And this global container number is a lot, we now own statistics is that the world is 52,000,000, is especially after the epidemic (COVID-19) this figure we initially estimate is 52,000,000, now the global flow (circulation). In this big background, we involve to some cold chain transportation (cold chain), such as cold storage (under refrigeration) based transportation, and some transportation of dangerous goods of some cargo demand, on our intelligent demand (and) requirements are higher and higher, that is to say, our entire industry, especially like China's That is to say, our whole industry, especially like China's technology companies, they pay special attention to this kind of is the Internet of Things equipment application requirements and intelligent monitoring terminal (monitor&control user interface) can be comprehensive to control the temperature of a data. It does this kind of intelligent means (method), is in order to better provide service to the customer, that is, my goods delivery handover time will show the customer a temperature of a change curve, prove that I have been controlled in the -6 ℃ this temperature range within, my transportation quality is to get the guarantee of guarantee, so that now the application of this aspect This is the second level of my understanding about the development of digitalization and informationization.

Then the third level, my understanding of the future may be more, and we are now this kind of AI ah, or big data modelling applications to combine together. For example, his container transportation, the future more to have more decision-making policy decision and planning.

Our first and second phase more (focus) what? (is) our management, is a kind of improve our management means of a convenience measures Convenience measures. to the third stage, it will in turn affect or guide us to carry out a scientific decision-making and scheduling.

What we call it now, that intelligent scheduling and management of some of these applications. I currently also have some simple applications, such as their manufacturing production of that gate, he will install montage what? This container box number identification system, the box

number identification system (system to distinguish numbers) and some of my background data system together, forming a container big data analysis system.

A company if it can put all the containers are to realize an intelligent control (manage&control) management, that is to say, through a variety of information, different information of an intervention, and then realize it the whole of a data analysis, it will be my whole container that box running condition, including the quality of that operation to carry out a prediction and processing. In this way, in turn, will guide my container owner is the box owner or carrier, can do a better judgment and decision-making on this transportation. That is, we are currently in China, especially I have on many occasions on the container of this information technology development stage (summary), I am basically in accordance with the three stages of the introduction. Then our industry is currently underway is the second stage, that is, including our working group with, as well as the working group convenor engaged in that TS7344 standard, in fact, my understanding, this is more we in the second stage of the application of Internet of Things technology, this stage of the follow-up follow We may be more towards match big data, big model, the application of this stage and a variety of AI technology The first question I'll briefly introduce. This first question I will briefly introduce so many.

Researcher:

The next question is: Germany has adopted a decision to use IoT devices in every container, so that every container can be tracked (*zhuizong*- traceble) in this way. Germany recently made a decision, and then I would like to ask, what is the view of this (decision) Director Li?

Interviewee 7:

After I saw this, I was the first to raise my hand in favour of this practice.

I was very much in favour of our German company's proposal that all newly built containers should be equipped with this IoT device.

When I saw this, I shared it in a speech, and I think it's a big trend that's not a problem, and it's a necessity of our time. At that time in the conference exchange, I passed this message to

everyone, people are also asking, especially some traditional this shipping people asked me back, he said, this is a good thing, but the cost has increased again, who will pay for it? （How much of a difference will it make? Many, many (similar) questions were raised. That is to say, this thing can be done, but it is this kind of cost, this kind of additional costs, how to get the problem. In fact, after (on) some of the cases in the past few years some thinking, I think that these things ah, to put it in another perspective: the first is the installation of Internet of Things devices, this thing is a big trend, is certainly to do, not today, not tomorrow, in the future there must be a day to do this thing. But why does the industry now have the feeling that it is a good thing, and there are still people mentioning the voice of opposition? It is because we are now on this kind of IoT device access ah, he did not have a distributed implementation of a consideration. Right? That is, now the public that ordinary cargo containers and refrigerated containers, including the transportation of dangerous goods tank containers, (about) their Internet of Things devices, if you can establish a distribution, classification, a progress of implementation. (I) and my colleagues said, we general containers, such as ISO1496 container, it has a basic positioning function, may greatly meet the requirements of its tracking. But (if) involves (to involve) to iso1496 refrigerated container, we have to consider to add a few strokes on the basis of my first tier. For example, the first level, I have a positioning, the second (level), you have both the positioning function, it has a function of temperature monitoring, and then to iso1496. just this kind of irrigation container, what pressure ah, some of the various aspects of the requirements, that is to say, (if) it is the implementation of a step-by-step progressive Internet of things device access strategy and principles, then, it can be better accepted by everyone. Because without the principle of categorization, or this consideration, everyone, including us, first think of this monitoring ah, this demand is so much, I want to put this device at once (installed), the cost will increase a lot. In fact, if you follow this classification management, or after the classification of access, can better promote this kind of IoT device access. Then now in China, at present, because we are responsible for China's container standardization work, I am in many occasions, and then also began to advocate that the intelligent device, or the Internet of Things terminal to have a classification classify and classification categorise and then guide instruct the industry to carry out a classification access. In this way, it will be able to meet the minimum requirements, and then carry out a gradual access, (so) the industry will be earlier to accept it, earlier easy to be able to make this device in all the containers to carry out a popularize, so that the effect of the results obtained effect may be a little better, to avoid everyone because of the purely only consider the cost, the current

input cost, and the impact on the cost, the current input cost. The current input cost and affect the access and application of smart devices. This is my consideration of this issue.

Researcher:

But where does this technology come from? Should it be Chinese technology, but still you would want to use technology from other countries as well, like from the US, from Taiwan, or from Europe? That is, what is your opinion, or preference, about the origin of this supplier that provides technical support? For example, China is preferred, or it doesn't matter, it's just whichever origin is fine. What are your considerations?

Interviewee 7:

I think there may be some industries in China, there are different ways of saying this kind of, whether to use Chinese technology or American technology, right, and then whether it's developed country's technology or developing countries. They have different purposes and starting points and different interests. But in China, especially in my management of this container standardisation of this field, we form the same consensus, not only our water transport institute (Ministry of Transportation Institute of Water Transportation Science), including CIMC - they are the same. Our container needs a global use of the device. Which technology we use, with which products should be to follow international standards. We never from that in the end is the Chinese technology or American technology- to consider the accessibility of this equipment, adding more emphasis on the global use.

At that time, we put forward a very typical point of view, that it is your container and you add a smart terminal manufacturing equipment (smart device), only you in China can read (read data) – it is of no value, only in China, only in the United States, Japan (etc.) Only when all the countries are able to read your data from the installed device, it can be counted to be global, it is globalisation.

Researcher:

I see.

Interviewee 7:

Therefore, we put forward a point of view at that time, that is, no matter which company provides the technology or product, you have to comply with an international standard, and the compliance and universality of the standard can be achieved. This is one of the most basic requirements for us to promote containerized intelligent terminals. I have been emphasizing or reinforcing this concept on many occasions.

Researcher:

Is this the same standard for hardware and software?

Interviewee 7:

Software means, you are such software, it's from American company, (then) you decide (how) you build your backend system. And then, Japan you set it yourself, how to build it. We just have to make sure that everyone's information can come out through the IoT terminal devices, and we can realize a cycle of information.

Researcher:

I would like to ask about the technical support provider, is it the same in terms of hardware and software, as long as it follows the two standards, international standards and global standards, right? It's the same on the software side as well.

Interviewee 7:

Ah, yes, it's the same on the software side ah. One thing that's special about the software side is that at that time, ten years ago, I think, that was when, I remember it was 2011, 2012, those years, when there was a meeting in Malaysia and Singapore. At that time, we were still discussing whether to build a global information management system for containers. I remember that Lars was at that meeting. Everyone's view is that each company can build its own, you just need to ensure that your data transmission is in line with the requirements. That is, maybe COSCO's system is developed by Chinese people themselves, maybe their company's information system is developed by their own company, but I have to comply with this kind of international data exchange agreement between the two companies, to be able to carry out the exchange of data. There is no need to establish a globally uniform, a hardware product or a software product that follows the principle of openness.

Researcher:

So, in terms of China, there is no preference in terms of origin, so what do you consider in terms of choosing these technology suppliers? Or are you looking at cost, for example?

Interviewee 7:

Haha, yes, when it comes to this kind of products, both software and hardware, for most of the shipping companies in China, first of all, the price is a very important factor to consider, right, because it has to fit the actual situation of the work, but the price is not the only factor in the shipping industry, that is to say, it's a very big influencing factor. The most important thing, especially in container transportation, is two indicators, one is accuracy and the other is reliability. One is accuracy and the other is reliability, that is, I try to make as few mistakes as possible during the operation, and then not to have an impact on my production, which is the most important core indicator.

And then as the efficiency, or the volume of transportation increases, the demand for reliability and stability slowly outweighs the commercial considerations of price. First of all, I want to ensure continuous production, continuous operation, this is my system, or my transportation system to be good. That's one of the most central and fundamental points. So, you might see a

marina or a shipping company that buys a product or a piece of equipment, and then ten years from now it's still the same supplier that's doing it for them, because throughout the course of the upgrades and the maintenance of that system, it's going to be able to ensure as much sustainability as possible for my production.

Researcher:

Yes, thank you. And how do you and your organization use the smart boxes, the data that you collect through the smart technology?

Interviewee 7:

First of all, from two perspectives, the first one is that my organization is the Institute of Name of the Ministry of Name, and then we are a scientific research institution, we have our own laboratory, we have our own container experimental yard, and we do all kinds of container experiments, especially the development of intelligent products, (these) are more for the future to meet the industry's needs, the industry (related to) the need to explore the technology, rather than to carry out the development of the technology, (these) are not for the future. We are doing all kinds of container experiments, especially the development of intelligent products. Therefore, we are currently, the current research institute to do this kind of electronic label application, more is (in order to) test this kind of electronic label stability, reliability. (For example) we are actually operating in the mode, the application is good? More from this perspective, this is our laboratory stage.

Then like some logistics companies, including their shipping companies, their terminal applications, or the application of intelligent products, is (in order to) meet the needs of his own business. At the current stage, I have dealt with them many times, and we have also guided them to do product development, they are more (in order to) improve the quality of this kind of cargo transportation, to be able to undertake more transportation business. From this point of view to do, not because I added intelligent equipment, my input costs increased, he put the price up, in fact, they invested more costs, and then realize the better quality of transportation and transportation services.

So, we have these two application modes, it determines our data processing is significantly different. We actually have some products for smart containers now, and I can send you an email to show you and a video later. Our data is basically open, a collection, testing ah, and then that output ah, for everyone to see, without involving some of the commercial situation, whereas these companies is like COSCO, this kind of shipping company, it data collection and processing is the company's own internal processing, and did not give the data to other people, that is, he maintains his independence.

Researcher:

Yes, clear, yes, okay. So, in terms of research, you are fully open, but if it comes to business, the company has its own decision making and management, right, and it's generally internal access to the information, it's not public, right, that's understandable, right.

Interviewee 7:

Yes, yes, and then between the two models ah, we also gave data to some companies, for example, COSCO; another one can be Maersk, we are trying to provide them with a third option, that is, we suggest that they can be able to data kind of involved in the commercial part of the content of the elimination, and then involved in the simple transportation, the container status information, to achieve a basic sharing of such a case, so that they can share the data with other companies. In this way, they can realize a basic sharing of data, for example, Maersk’s data and COSCO's data have a shared base data, which is more conducive to the sharing and exchange of data among different companies around the world. You remove your own business information, that public information, especially some of the information related to transmission, if you can share, it may be more conducive to the development of the whole intelligent container, industry intelligent transportation. When we give advice to different companies, we will give them some relevant advice, that is, both their own independence, but also to consider a compatibility with others.

Researcher:

Right.

Interviewee 7:

Maybe you'd be better off in the information age.

Researcher:

Thank you. And then the next aspect of the question is something about standardization, which is your company or your institute, what standardization organizations do you participate in and what are the reasons for participating in them?

Interviewee 7:

In China, there are several types of standardization organizations, the first one is the government-led standardization group, the most typical one is SAC, which is the standardization organization led by the Chinese government, which is equivalent to the national standardization as a basic work, open to the society, a public welfare, and a country to carry out a relevant standard development and industry promotion. The starting point in this regard is more to meet the demands of the industry a public interest.

On this basis, we also have similar standards to foreign associations, such as the Chinese association for standards, China also has a number of related associations for standards, more industry kind of major enterprises, especially based on the commercial point of view, from the industry application point of view, ah, to develop some group standards. These standards, the association is clearly advocating the interests of standardisation, including some of the technology, there are from the intellectual property rights related to the protection.

That is to say, like the government-led SAC-led standards are basically open to the community, are purely public interest. Then some of the association's standards, more from the industry application at this point of view to carry out. These are two standard models.

There is another kind of standard, this kind of standard is what? It is similar to a loose, a few companies to carry out a joint alliance of the application. This standard and association standards and state-led standards are very different.

The alliance does not have independent related to some standards, but only as a technical document, we share the common use. Our kind of research institutions, scientific research units, these three types of standards we basically participate in. Like, I myself, is the Ministry of (Name) of (Name) Research Institute of researchers, but I also represented, to manage the China Container Standardization Technical Committee (Name) is Technical Committee Number this, and then I also participate in this kind of industry associations of some of the standards. In addition, I also understand some alliance standards. Through this whole, the understanding of the industry's standards, we can learn more about the status of industry standards and development trends, and in the future to better support the introduction of relevant standardization policies for the state, for the industry associations have any standardization needs to provide them with some advice. Our research institutions involved in standardization, more from the perspective of a third party, to be able to put forward our insights on the development of some of the industry's standardization. Of course, we give you this kind of advice and provide insights to the government is a free service. (But) we sometimes provide some technical advice on standardization for some companies, and the companies will give us some fees. Basically, these are the two models, but no matter how the model develops, the core is in the field of containers. In addition to the state, there are industry associations, including the Alliance's standards, we are deeply involved in the future, ah, can deeply understand some of the dynamics of the industry, and then can be published from time to time on some of the changes in the industry some of the views, can advocate or push a new model or new materials, new products, an application, or more with the industry's development of the combination of the more, because it is a little bit similar to the Foreign university teachers.

Researcher:

That's the industry association, just now Director (Name) mentioned SAC.

Interviewee 7:

SAC is the national one, the national one, yes, SAC, China Association for Standardization.

Researcher:

Okay. And then the federation doesn't have that number, right?

Interviewee 7:

The technical support for the alliance is like that; there is no number because it's only when the association is registered that they have a number.

Researcher:

Okay, thanks. And then, just from your point of view, to what extent is the digitization of this container supported by the government or subsidized by the government. Is there any government support, Chinese government support or some economic subsidies from the Chinese government for this digitization?

Interviewee 7:

The first one is the digitisation of containers, which is always supported by the Chinese government. My understanding ah, not only the Chinese government support, including my understanding of Singapore, Malaysia, South Korea, they are very supportive, because we can see that through the development of intelligence can improve efficiency and security. This is no problem.

Then, the second, why now intelligent container development is not as fast as we expected, a big reason is that governments support the development of intelligent containers, but the container industry did not get a penny of government subsidies, this is precisely the industry has been more entangled place.

Because I slowly thought of this, how the government from how to show his support? How many (many) documents are more supportive of everyone to the intelligent, intelligent transformation, but unlike some industries can get some subsidies from the state. That, my understanding is that China, including some neighbouring countries, I understand that some countries believe that this container transport is a very market-oriented, a market-oriented characteristics of a more obvious industry, so they rarely get the national subsidies on this industry. Unlike a new what intelligent robot, or what that intelligent, a what new products may get some scientific and technological awards, but the container this piece, should be more due to it is highly market-oriented a thing, did not get the governments (subsidies), but with the intelligent container related to a number of such as what transshipment equipment ah, the port facilities, ah, may get the different countries and regions some preferential policies. region's preferential policies. But purely from the container itself, within the scope of my understanding, we do not get the national subsidies, so that the market for the community in the hard to grow. If you get subsidies from a country, I believe the intelligent industry in that country should grow very fast.

Researcher:

What do you think about 2025 Made in China?

Interviewee 7:

Researcher mentioned a Made in China, 2025, which is a plan at the national level, right, to achieve a leading position globally by 2025, and then I've been working on that international standard, but he thinks it's because of an idea, an initial idea of Prof. Pao himself and his team, so is there any idea, any expectation from the level of the national committee, that is the national Committee at this level, what is their vision or plan or expectation for the future, rather than initiating it as an individual or an individual organization of an individual group.

This is just like I just said at the end of the ah, that now the container industry, according to my understanding, each country is considered to be a highly market-oriented product, that is to say, do not enjoy the government subsidies, and then also do not enjoy special preferential policies,

one of the most important reasons is because of the feeling that this is a global, and in the countries of the industrial policy inside the container as a particularly high-end industry to treat, and the container as an industry. A particularly high-end industry to treat, this is my current understanding. Including just what you focus on 2025 intelligent manufacturing China these huge programs, I can honestly tell you that the intelligent manufacturing inside does not include the container industry, because we feel that the container technology is not so (high-end). This kind of point of view ah, I personally, from my personal point of view, that may be right, and I am also more insistent, is inclined to this view. Why? That is, I have been engaged in transportation since I joined the work, from the concept of transportation, our transportation equipment should be as cheap as possible, to be as stable as possible. It's not very safe how it's done. So that we pursue is a kind of provide low-cost, reduce logistics costs, this point of view, so that the previous container ah, it is not from the high-end perspective to more to consider, with the development of such an intelligent one, the future of the container, an emphasis on its own a security, security to be guaranteed, the other is the wisdom and information, this aspect of the requirements are also more and more high!

So now the container began to slowly get rid of the previous is a heavy, thick, long, big, a stupid iron box of a concept, and slowly tend to it may be a smart, it is able to interact with you a transportation equipment. Everyone slowly to this concept to change, in the process of this change, in fact, this kind of society that the electronic information industry, or engaged in technology companies, engaged in technology industry may be a little more concerned about this. And transportation and logistics itself is slightly less concerned about this. My understanding is that we have to establish a subsidy for this kind of container, especially the smart machine container, or to give a preferential aspect of some of the considerations are less.

I personally believe that with the transformation of this traditional container to smart container, this trend, slowly on the smart container that promotion ah, countries may be corresponding to slowly consider, give some convenient conditions, these convenient conditions, of course, not necessarily money. Through the development of smart containers, in this kind of international trade to facilitate customs clearance, transport facilitation and so on can give some more conditions, such as our highway ETC fast lane mode, may also slowly put the smart container in this kind of industry in an understanding and status will also slowly have a little bit to improve, but this process may be relatively slow, but with the development of the whole society, especially on the With the development of society as a whole, especially for the global container

that intelligent scheduling and management of this demand continues to increase ah, this aspect of the awareness of ah or this aspect of the understanding may slowly improve some.

Researcher:

I asked all the questions about my interview, (and) I got a lot of important information, information about the research that is important for me. It's this doctoral research, it's very interesting because I talk to my colleagues, I ask these questions, and there are a lot of special views, for example, that China is not very good, because the equipment is not the same as the European or the American standards. Especially after working with Prof. (Name) for more than three years, I get to know that (what they think) is not the real situation. I think we can accomplish more collaboration together. So, I wanted to write this study, and I had a couple of expectations.

First, I want to get this PhD title. Secondly, I need to tell our colleagues that through this research of mine, they can have a better understanding of the situation in China. In the West, in Europe, China is still not well known, because there is no first-hand information and data. So I hope that through this doctoral thesis I can introduce, or make a name for, manufacturing in China or standardization in China, which is not as bad as the common belief that the standards are different and worse. So, if you have any other research on China to help me out, I'd appreciate that as well. I found a paper that you published in 2020 on smart containers with another researcher, and I would like to ask if you have any other texts on this topic.

Interviewee 7:

No problem, I have some articles on this subject, I'll send them to you by mail.

Researcher:

That would be that would be great, thank you very much. And then just wanted to ask if you have been able to recommend any industry staff, or industry related people who would be willing to participate in similar interviews, for similar interviews.

Interviewee 7:

Good, no problem. I, I report my identity, I am in addition to this (Name) Academy of Sciences to engage in research in addition to ah, I also in the (Name) Container Industry Alliance Secretariat as (Title), and this alliance is specifically for the development of intelligent containers was established. Why do I know that the alliance some things do not have a standard number? Because the alliance is everyone in order to technology sharing and sharing in a piece of an organization established, I itself in this organization as a position, I am now when the (Name of Organisation) (Title) , if you have any needs on this side, I can be from a different perspective, including our hardware, including some of the software to do the interface, I can be introduced to you, no problem, I'm expressing this, this is no problem. Another one I also send you an invitation, is that our alliance ah, every year to organize a global event. Muskie, they also have representatives to participate in this year's May when there are activities, if you have time, we can also invite you to come, if you side cannot get out of the way, you can then we open a video conference, we invite you to participate in also into, right.

Our annual general meeting is to discuss the intelligent container, this year to focus on what cooperation ah, to engage in which to develop the future outlook of the market prospects, is our alliance has been promoting the development of this intelligent container, and then Muskie has two managers, but also often participate in some of our activities in addition to several foreign telecommunications companies, including the United States of America's SaaShun company. In the past, they were all involved, just now I especially thank you for saying that many people abroad do not understand China's standardization, do not understand the situation of China's intelligent products.

In fact, this is really true. About this container, this intelligent some products ah, we do not understand or do not know the thing, the earliest in China for electronic labelling product sales is precisely the United States company, is the 3A company, is they do SAV, the beginning is they do the electronic labelling, in China for promotion and sales, and then so.

Researcher:

So, I'd like to ask, how should I mention your two positions in my paper or how would it be better to mention you and how would it be more helpful to you in terms of your business or in terms of your career and so on?

Interviewee 7:

Thank you very much. I'll take the name of the Ministry of (Name), (Name) Science Academy can be, because the Ministry of (Name), (Name) Science Academy in China is an independent third party, is more recognized, in China is still more very recognized, a neither government managers, subject to a variety of constraints, but also no business this kind of commercial behaviour, we are relatively is similar to foreign universities, is quite independent, a third party ah.

So, my thinking is very often to promote the development of my transportation business through intelligence and wisdom. That's why I am more concerned about this aspect. Because of this kind of thinking, including me and some electronic label developers ah, often there will be some intense thought collision. Because they develop electronic tag of some products (when), always emphasize me this powerful, long use time, more emphasis on the performance of an electronic product, I often say with them, to change the dimension, intelligence, intelligence is for the business services, you this product to help me achieve the minimum requirements can be, you 100 dollars to help me achieve my transport function of the optimization and management, you want to build 1000 yuan to help me achieve that! and management, you have to build 1000 yuan of things, that although it is also realized (requirements), but I think the cost is a little expensive. So, we have been talking to the developer, you have to have a balance between the two, it's okay for you to have a little more than 100, right? I in order to realize a better claim, add a little bit of money can, but cannot get too high, (if) you get too much, the company cannot operate, there is no way to get. So that's why I've always had to advocate a balance between this price. Because of this point of view ah, about this container intelligence, my thinking has also slowly changed, that the most typical is that I have been in China for several years in the promotion of this container with a two-dimensional code, our usual two-dimensional code with a cell phone to scan a sweep on the line. But I now put the two-dimensional code for industrialization, made into a square, probably 30 cm by 30 cm, stick it to the container, stick it to the car, and then use the cell phone to sweep,

will soon be able to realize my box number ah, the identification of the car number, and this two-dimensional code of the cost is very low, make a two-dimensional code on a few dollars, and I also use a sim, that what the label to go to make.

That is, we are now ah, in the development of this China in the development of economic intelligence, I put forward a very important point of view in this industry, that is, what is required for large-scale use, low-cost use, reliability use. I said, as long as you are in line with the first requirement, then we can help you to promote the industry, because I do this thing is for the development of the industry, because I am an independent third party.

Subsequently, if possible, may be the first, if we can do a standard, we still can we join together to do a standard, the reason why I now want to make it an international standard, is because this low-cost application in China has achieved a certain degree of success. I was in 2018, this kind of product just put it that scale, industrialization. As soon as it came out, so far, I have installed nearly 1,000,000 accurate data on containers in China, it should be 920,000 containers have been installed with a two-dimensional code, and China's railroad (department) has clearly issued a notice, all the railroads newly built containers, just like our German company, are required to require shipping companies to require the installation of that LT equipment. I this Chinese railroad is required to install the QR code, because the QR code is just a few dollars, just three dollars, five dollars on the paste up, and does not involve the interests of the product between. But the cell phone to achieve a scale of an application, do not need to add some additional costs. The company wants to move in the future, as long as they build their own system, it can be. I, I think this this model, if in the future can be combined with our current intelligent devices, then it may form a complementary situation, more favourable development.

Interviewee 8, December 13th, 2024. Zoom Call. Preferred language – English.

Interviewee 8:

What's your topic? on the containers?

Researcher:

in particular Chinese small containers.

Researcher:

So how to do containers Smart?

What is important for me to ask you is your consent. I sent you the letter of consent.

What would be your preference?

Do you want to be mentioned by name and company and company, or should I, make an Interviewee 8?

Interviewee 8:

No. Don't mention my name. And, because this is same, I'm not a public company, so all these just, you know, all personal communications; and to some extent, I'm a big, big name, so I don't want to disclose myself, because I know the PhD will be kind of public in future. So, this is exactly very important, that especially in the publication will be mentioned interview one- two, three and no personal.

Researcher:

Can you please tell me, how long are you in this industry of containers?

Interviewee 8:

Oh, God. From I think, I think from 1990 or 91 till now. So that's very long and I've been,

many parts of the business, many sides of the business, being a container manufacturer for

more than 20 years. And I've been working for leasing company for five years, and I've been working for a supplier or Pine Company for less than a year. So, yeah, I've been jumping in and out a few times. So yeah, it's almost my lifetime job.

Researcher:

What is it for company’s approach to digitalization?

Interviewee 8:

You mean digitalization of the products?

Researcher:

The containers.

Interviewee 8:

Right. Containers.

Researcher:

Yes. And we can speak broad here, not only reefer, dry, or tanks.

Interviewee 8:

I just feel it's quite complicated. You know, for say different categories of containers. It's all managed by different and owned and managed by different stakeholders. I think the interesting part for our business is that we have a major player for leasing companies and as for what you want to do on the container, what never mind, it is reefer box or dry box or a tank container, whatever you want to do, to add on to a container- It needs to be approved, acknowledged by the owner or the buyer, because they have a huge buying power and they dictate what they want and also they dictate what they don't want. So even sometimes when you say, okay, I give you this for free, they say, take it off.

And so, if you look at the customer side, the leasing companies don't really have an interest in the, the smarts or digital accessibility, you know, like the GPS, like the utilization, because for a tank

container, the leasing company, well, digitalization brings up the efficiency or utilization of the asset, but on the other hand is counterproductive to their fundamental interests. So, they want the asset to be less efficient. And the digitalization would help to improve the utilization.

So that's contradictory to their fundamental interests.

And on the other hand, even they are interested in getting it. They don't have access. They aren’t getting an access to the data that they should not know.

And the, the leasing company, the shipping lines…maybe not the shipping lines.

And for our business, we've tried, the digital, smart device, a smart device, up to ten containers for many years. And the operators were basically saying, we don't want to put this on to our asset.

You don't need to know on our business because they know once you have the digital device onto their asset, then we have access to their products. And they don't want us to know their business.

Researcher:

I have a question. you have especially in think containers, all this type of, damage protection plans and so on for, for the cases the tank, for example, is not coming back in good shape. Would it be any influence when if you know how your tank is operated?

or saying that a smart container can reduce your insurance costs because we know how many times it was damaged?

Interviewee 8:

it's a good concept, but the chance you really use it is very, very small.

Researcher:

but when you think about smart containers in your mind: In general, what would be the use case for a smart container? What would be the application?

Interviewee 8:

I think it's good for some very, sensitive high value products and a high value, very special, dedicated operation. You don't really need that for the daily operations, you know? And actually

for the dry boxes, the fleet is so big. And the, you know, the subscription fee, will be too big for any shipping line to pay for it. So, the shipping lines, they have their own system to manage the fleet, and leasing companies doesn't have the incentive to manage the fleet.

Even they got the message, they don't need to understand. They, you know, for a leasing company, they're happy as long as they lease out the container. And also, they get the container back when, this deal is on due.

Leasing companies: 50% of the ownership has no interest, no fundamental interests in the smart.

Researcher:

How do you explain the Hapag-Lloyd?

Interviewee 8:

They may be, they may be, but if you talk to Textainer and Triton - they don't care because yeah,

as long as they get the asset back on time, we can find the asset. They are happy.

So, so really the 50% of the ownership doesn't really care in the world.

we only need to look at the other 50%. That's the shipping lines or the operators of the asset.

Researcher:

But why full fleet I mean why do you think Hapag Lloyd's decided to go full fleet:

They went 2019 all the reefers and then 2022 all dries and no one else did it.

Interviewee 8:

I think it's a German thing. It's really the German thing.

if you if you look at the tank containers, it's also the German, like Hoyer. You know, if we ask any non-German companies, we don't really care, right?

Researcher:

It was Hoyer, Bertschi and VTG who decided to put the IoT on their tank containers.

Interviewee 8:

No, even I don't think Bertschi has put many on it because if you look there.

Yeah, we built most of their fleet.

Even Hoyer, they are kind of installing that afterwards.

So, so it's, it's really a German ego thing.

Researcher:

when you think about technology that you can use to digitize containers today, what comes to your mind? RFID tags, IoT devices. What is for you a digital smart container?

Interviewee 8:

Well, so for me, so digitalization of the products really helps to, hopefully, to improve the utilization of the assets and also to…well, so let's look at from, say, following what is how do you, how well in Chinese we call it predict predictable because, you know, what's the status like, like for a tank container, you know, what's the pressure like, What's the temperature like. And then, you know, for the sensitive cargoes, you can predict what's going to happen and when you can predict, you can prevent the problems and then you can intervene.

Researcher:

Which type of technology for your opinion will serve this purpose? Do you know the difference between the device and tag?

Interviewee 8:

Yeah. We are adding say temperature sensors. We also put in the pressure sensors and, of course, you know, we are putting let's say the GPS. So, you know, where the tanks are. But the, the trouble with GPS is really, the accessibility of the signals.

Because on the sea, you don't see it when the container is buried in the stack is the container.

And under the deck, for example, on board the vessel.

Then it's also very difficult.

So, on the other hand, I don't know what's going to happen.

So, has anyone tried? I assume nowadays the big vessels, capacities almost 24,000 TEU

and assume if you have every one container has a GPS, imagine, what's the confusion like going to be like you're talking about almost 15,000 different units, and then it's going to be really chaotic.

Researcher:

And the one of the ideas, you know, this digital container shipping association- they released in 2019 that it should be infrastructure on the vessel that will support different types of communication. And you need to put relay that all these containers will talk through the vessel infrastructure to the cloud. I don't know if they really considered calculated the power consumption and pressure on this infrastructure. If all 15,000 units will speak and should be conditioned to, for example, the critical events, because you

don't need GPS, what you need, it's probably from reefer units, the temperature deviations.

Interviewee 8:

I agree I agree with you. So, you need to have these things on the reefer containers actually, the reason machines already had the communication or accessibility with the vessels already for more than ten years. And, and also we had I was building tank containers, with such kind of, technology and especially now we nowadays we we're not making some, cooling tanks and also the heating tanks, so, we also, once the vessel know what's happening, what's going on, when putting tanks, what's the temperature like, on the cooling tanks or the, the heating tanks.

And for most of the other kind of normal tank containers, I think the history experience has already proven that, well, the facility is good enough for the normal use.

If we if you load the right cargo to the right container, you'll be safe, because nothing happened over the years. So it's more a disciplinary thing. But if we put something new, if you like, if you have a heating facility, if you have a cooling facility which is plugged into a power plug, then there's some inconsistencies that may happen. And then the vessel needs to monitor the change of the temperature with the container or the cargo, because some of the cargo, if it explodes- so certain temperature may explode.

Researcher:

And if you choose, you say you are building this, smart tanks, but when you choose the technology provider for the sensors and pressure digital sensor, do you consider? Whom would you prefer, a certain country or a region like made in China? or you can look at Made in Taiwan, or you can look at made in USA or what would you prefer?

Interviewee 8:

Well, I think, for the electronic instruments, it's mostly made in China, but maybe the brands come from everywhere in the world. Whatever is applicable.

For the application, it should be global because we can't confine ourselves within China.

So and, and mostly for such kind of applications more to the heating cooling tanks, and we, we are now trying to kind of…the other the other thing is we, try to fit to the kind of say it's not really core infrastructure, but it's kind of, we have built in the kind of accessibility to the sensors or the display, because if we are a brand new container manufacturer and we do have the kind of privilege of preset the cables, wires onto the tank barrel. So, you know, when you want to put a sensor and then you have it just plug in and not if you put a such sensor or display on an old container where there's no cable there, you have to kind of rip the whole including insulation and then that's and of course, it costs a huge, fortune on the labour and material.

So, we, kind of planted in the cable. So, you can if you, in case you need you just plug into the sensor and display and then you can play.

Researcher:

But I understand that these are digital sensors.

Interviewee 8:

Right.

Researcher:

So, you will have their information, for example, on your computer, on your phone. Right

It's an app that will collect. Yes.

Interviewee 8:

And so rather than make it ready for every take live online, they will we need it or not.

We are putting the kind of infrastructure ready and, in case, just in case, you know, customers need for 1 or 2 unit, then I think then customer may be willing to pay some premium to because it's just a one off or ten off. They will be happy to pay the premium.

If you want them to install for everyone, never mind if they need or not. For even for a small money, they will refuse it.

Researcher:

Do you assume how they will use the data collected from Smart container? How will you use the data? Who will be owning the data? Who will be using?

Interviewee 8:

Well, I would say technically we have the access to the data. But say for, for the safety, for the moral issues, we don't want to see the data. We don't want to know the data because, you know, we are providing it's a ten product to the customer and the customer wants to write that, hey, we don't need to know their business. So, it is really up to the operators to yeah, especially the operators to know where their assets are used, where the content is, whether it's loaded or unloaded, whether it's too hot or too cold.

Yeah, it's all operational issues. I don't think it's even, a leasing issue. The even the leasing company doesn't need to know leasing. Leasing company only need to know when the container, when the right lease is on due. And the container is not delivered back. And then they need to find out where they, they can just recover their assets.

Researcher:

I understand that from the ethical reasons, you don't have any an intention to share this data.

But do you think that the operators would be interested to share this data with port authorities, the cargo owners themselves, to other organizations, other freight forwarders that are working with them. Or it will be privately kept.

Interviewee 8:

Yeah, I think, it's up to them to distribute such kind of information. But for the common fundamental information like the certificate of the container, we do have QR codes on every one of our products. When you scan the QR code, you can find out the certificate, individual acceptance certificate of the container. And also if the owner manages the assets properly

and if they load, if you can even upload every maintenance, every annual review onto the system.

so you can see where and when, where and when it was kind of maintained, repaired or kind of annual checked.

Researcher:

Do you know if your organization is participating in any standardization activity, standardization bodies, national or international?

Interviewee 8:

I don't think such kind of organization really exist, especially for small business.

yeah, we are always there with the ISO, but it's quite fluffy.

Researcher:

but there is, standardization association of China-SAC.

Interviewee 8:

Right. I'm not sure we are in there. I'm not sure, not sure.

Researcher:

Because I wanted to ask you about the interest a technological interest of national committee.

Interviewee 8:

No, I don't really know.

Researcher:

And, do you think, and that was a provocative one, and I will explain you the background of the question further:

I was, absolutely obsessed by Made in China 2025 policy. this is your government's policy that plans it till the Jubilee. Until 1949, next to 2049, right to, to reach the steps of, digitalization in the whole industry, not only our industry, but in general, right in, in the production and so on.

So first they said we want to catch up with the digital trends, with the Industrial Revolution 4.0. Then we want to advance. And then towards the hundred years

2 billion, we want to lead it. And that was reading a lot of, policies to this point. And was reading in Chinese. It took me years, honestly, to understand that. I have an assumption

then. The word digitalization is in the public policies that these attempts to digitize should be subsidized by government. Do you think?

Interviewee 8:

Well, the government is kind of supporting, first, from policy side, they are kind of supporting it. But I don't think it's possible to talk about the topic. Well, because China is so big, the country is so big. So, I really doubt it is possible to arrive to 100%, but, for the manufacturing side, it's most maybe for the consumer side, maybe it's possible because consumers basically individual consumer has no power. So, like say your everyone has a mobile phone and then you're being watched and listened all the time, you know, never mind if you like it or not. Somebody is listening to us all the time. So, so I think I think for, for consumer market, it's most likely because they have the access to the data no matter you like it or not. But for the industrial products, especially the industry like ours, they buy when the buyer, when it's more kind of B2B, especially the B a very big when they have a determinant of power, when they say we don't like it, you don't put it on.

And then they have their closed loop to do the things. But digitalisation on the manufacturing process wise, we are also working on it. And government is kind of incentivize factories companies to do it. But I think the even the level of the digitalization could be different from cities to cities or provinces to provinces, because the people who judge it reviewed it are different, and it is more kind of political or, kind of fair game playing. So, so a good one, like a bad one or none a fair one. In Jiangsu Province, you may know Jiangsu is one of the best provinces in China. A fair one in Jiangsu in our province could be really a top notch one in the kind of remote province, like, Gansu. So, so there's a of a very big imbalance of technology and economy between different regions.

So, so it's really hard to judge whether it's possible or not, even when governments say we've done it.

Researcher:

Can you apply for subsidy and say we are doing digitalisation, therefore we want subsidies from the government for arranging. For example, can you do this?

Interviewee 8:

No, it's not for every company. It's, it's for the two role models. It's not everyone can get it. You can't just tell the government: Now I bought this for 40 for digitalization. Please give me the subsidy. No, it's not that easy.

You know, maybe, in the city like ours, maybe you know, maximum 3 to 5 companies, will get it. They would kind of do the horse racing.

Researcher:

Some of your colleagues said an interesting, element. They said that, if you declare the development of sensors or device or something for digitalization and you declare it is the R&D phase and not already commercialized product, then you can, kind of write it down from the taxes. They can get taxes discount.

Interviewee 8:

Oh, yes. No, I think the game is, because most of container factories aren’t classified as a, high tech company. But in reality, for a high-tech company enterprise you need to…I don't think you should put it into the essay… The truth is many companies are classified as high tech, but as the rule for high tech company is your R&D investment should be, I think, 3% of your revenue.

And, it will be for many container companies, they don't really put 3% of revenue as R&D. So, they're trying to find kind of excuses to allocate, just to build up the R&D cost. So, it's to a certain extent is cheating. So, yeah, it's yeah, it's just an excuse.

Researcher:

I have no questions anymore.

Note:

After Interview- small talk:

Interviewee 8:

So, what's your assumptions or, hypothesis?

Researcher:

My hypothesis is that there is a challenge of Chinese IoT technology for digitalization of companies to go internationally because of the data issues.

Who owns the data and who? Where's the server sitting and how to share the data. So, this visibility, as you said is an ethical question. So, if you're putting in as the manufacturer, you don't need to look at this. But why would they, your clients, trust you?

And the question on the tech origin, that you've answered this question perfectly- because you say it can be made in China. And many companies doing the physical works is in China. But yeah, but the data and filtration, the server should sit somewhere in Germany for example, somewhere neutral place.

And then I assumed that I understand digitalization. We had here digitalization through IoT device- sensor: data collecting, data releasing. And then I saw that for many Chinese colleagues, a smart container is RFID tag QR code or an E- seal on container. So, it's a passive reading technology because it works inside China. You can scan parcels, you can scan everything, but you can't get like real time notifications from constant scanning. So, for them smart container is not necessarily device on a container. It can be a QR code or

e-seals. And I didn't expect that it will go this direction because, I personally think that it's not applicable on international intermodal infrastructure.

Interviewee 8:

You don't have so many scanners that will be able to scan your code and especially containers may go to some welcoming places, like Russia, like, Africa, it's like a jungle and like a beach somewhere.

Researcher:

So, and I see the main disadvantage of this solution. When you see it's in Russia or in Africa and you lost your containers, you don't know where they are. How do you know? the tag will not tell you. So, this was this and my next assumption, of course, was the government supports, right, that we have a governmental support for digitalization. Support for companies like BoxPlus, the daughter company of COSCO that they will have full support. And they have been my first surprise, actually, that they don’t get any.

Interviewee 8:

if you if you look at the government subsidies in China, most of the subsidies, all the subsidies

goes to the consumer goods, not to the industrial business cargo. So, containers are very typically business goods.

Interviewee 8:

Yeah. I'll be more interested in…I know digitalisation of the container as a product.

To write any topic on that, it will be very big challenge because, it's hardly feasible. According to my experience, over the past several years.

But we are working very hard on the digitalisation, or I would call it digital transformation of the company, rather than the product, the product can remain traditional classic. I want my company the way of management, the way of manufacturing process be more digital. So, I am setting up a kind of digital, I put a lot of money and time and people on to the digital transformation of the company.

Researcher:

I saw it with, one Australian company that said that M&R process of containers worldwide is very underdeveloped. So, they are going for their own containers to develop a digital system that the vendor, the eventual vendor, will send you a picture and will check in the invoice in the price list.

This automatically send you approve and only then he starts repair and then he uploads picture again with the result and invoice. And you need to approve that.

Interviewee 8:

This technology is there already, you know, on the repairs and on the, on the even tank cleaning.

Okay. So, you just take a picture and then. Well, nowadays, the technology is already the picture can tell you the size the of the damage and how to repair it.

And then how much to pay?

What's the tariff?

It's that easy.

Appendix III Table Comparison of Research Questions to Codes and Quotes

Table 5.1: Findings per Research Question

Research Question	Code	Quote	Researcher Note
RQ1: What are the prospects of track-and-trace technology in global container transportation?	Approach to Digitalisation (subtheme: methods & applications)	**Interviewee 1 (Line 36-28):** *"regarding (container) digitalisation, it is currently a strategic focus for our company. Ever since the previous leadership took office, there has been a full-scale push to promote digitalisation".* **Interviewee 6 (Line 51-52):** *"I think today's IoT device much affordable, and I think the shipping lines have actually realised that today the container has grown to the certain size and it's difficult to manage without tracking them".* **Interviewee 3 (Line 397):** *"it's really, it's really happening".* **Interviewee 7 (Line 75-76):** *"This is all what we consider to be the second stage of container transformation to digitalisation or informatisation"*	**Interviewee 1** referred to the Chinese shipping line, which owns containers. **Interviewee 6** had a diverse background working both for container leasing companies and container technology companies. **Interviewee 3** was speaking both from the perspective of the Chinese shipping line and the IoT technology provider in China. **Interviewee 7** presented the official governmental position. **Interviewee 8** spoke from the perspective of the Chinese container manufacturer and lessor. The interviewee spent also years outside of China and had a chance to test different type of technology and

		Interviewee 8 (Line 400-401/227-228/101-102): *"we are working very hard on the digitalisation, or I would call it digital transformation of the company, rather than the product, the product can remain traditional classic. […] If you want them (leasing companies) to install for everyone, never mind if they need or not. For even for a small money, they will refuse it. […]* *Leasing companies: 50% of the ownership has no interest, no fundamental interests in the smart container".*	digitalisation models for Chinese containers.
	Future Innovation in Digitalisation	**Interviewee 1 (Line 201-203):** *"we aim to include AI-based container inspections and standards related to digitalization, creating a foundation for more forward-looking developments. We plan to finalize these standards"* **Interviewee 5 (Line 27-28/150-152):** *"In the future, with the development of IoT, the big trend is definitely towards digital operations. […] These technologies will enhance real-time tracking, improve security, and enable more efficient resource allocation. The goal is to create a fully interconnected and transparent supply chain that benefits all stakeholders."*	
	Regulations and Standards	**Interviewee 3 (Line 104-105/110-116):** *"I think it's a standardisation is still a problem here at the industry. […] Components inside of the device while the*	

		communication is a very complicated topic in the world and the container body is a kind of a standard. It's a kind of a product that following the ISO standards; we always see that the container is manufacturing with a strict standard as well as the transportation is being regulated by the international standards. Thus, if we install a smart device onto the container sometimes it will cause some compliance problems in some countries. That's how to see an issue and unknown problem." **Interviewee 5 (Line 157-159):** *"there is a need for standardised protocols and regulations to ensure compatibility and security across different systems Collaboration among international stakeholders is crucial to address these challenges and drive the industry forward."* **Interviewee 6 (Line 324-326):** *"So I know that there are certain requirements that they need to make sure that it will not be being "moralised" by any of the entity who uses the device or, and that means that all the IoT device providers are able to participate at the same time and also adopt the certain standards."*	
RQ2: What is the Chinese approach towards using trace-and-trace technology on the Chinese owned	Approach to Digitalisation (subtheme: German vs Chinese shipping line; subtheme; Chinese container manufacturer perspective)	**Interviewee 4 (Line 38-39/45-46):** *"Germany's approach of making every container traceable through IoT devices serves as a model for other countries. […]*	

containers participating in global logistics?		*Our company is solely a container manufacturer, so we are only involved in the installation of smart devices and have no deeper understanding of this area."* **Interviewee 8 (Line 120):** *"I think it's a German thing. It's really the German thing."* **Interviewee 3 (Line 85-88):** *"Well, for dry containers, we are at the starting point. We provide just much dry service to specific customers as per the customer demand. At the same time, we are watching the market response, especially the customer demand direction to see how much ratio we need to cover for smart dry."* **Interviewee 5 (Line 44-48/148-150):** *"Shanghai Port exemplifies this with three main levels of design: using internet technology for monitoring and tracking, ensuring safety and transparency through sensors and GPS. Another level involves cloud computing for efficient data storage and sharing, enabling effective data analysis, modelling, prediction, and early warning, enhancing port efficiency. AI is also being used to further develop these technologies […] With the continuous advancement of technology, we can expect further integration of IoT, AI, and blockchain into logistics processes."* **Interviewee 6 (Line 461-465): "***They (Chinese container manufacturers) do a lot of market research to*	During the interview, Interviewee 5 showed a preference of the infrastructure digitisation as the primary solution and container digitisation as secondary due to the cost factors.

		find out who are their competitors, what are their competitor doing and understand what they are, what kind of device they are using, what are the feature they have and so on. Then they were internally trying to develop similar kind of things to make sure that their devices are more advanced than the rest of the competitors." **Interviewee 8 (Line 200): "***For the application, it should be global because we can't confine ourselves within China"*	The statement of Interviewee 6 contradicts the statement of the Interviewee 4.
	Challenges in Technology Implementation	**Interviewee 1 (Line 75-76/134-136/139-141):** *This year, we also conducted some trials on dry containers. However, due to the unresolved battery issue, IoT devices on dry containers can only last for about one year. […] For example, how can real-time tracking for each container, especially dry containers, be achieved? We've been working on solving the battery issue for dry containers, but it hasn't been resolved yet. […] If the batteries have to be replaced every year, the cost would be extremely high, which I think is unrealistic."* **Interviewee 2 (Line 105-107):** *"Including the cost problem, including the problem of communication, including the core or battery problems, and so on, in the future there will be some problems with the international law, right."*	

		Interviewee 5 (Line 156-157): *"One of the main challenges is the high cost of implementing advanced technologies."* **Interviewee 7 (Line 237-240):** *"for most of the shipping companies in China, first of all, the price is a very important factor to consider, right, because it has to fit the actual situation of the work, but the price is not the only factor in the shipping industry, that is to say, it's a very big influencing factor."*	
	Intention of China in Standardisation	**Interviewee 3 (Line 339-341/344-345):** *"Actually, I think China is trying to do some standardisation for the variable industries. Because, you know, China is very big and the industry is, how to say, we speak about many industries, the chain is very long and yeah variable. […] Somehow, I think it may be similar even in in Europe or America, there's some industry associations and they create some standards for their industry."* **Interviewee 4 (Line 73-74):** *"Advancing national scientific and technological progress, industrial upgrading, smart cities, and environmental protection."* **Interviewee 5 (Line 81-84):** *"The goal is to integrate advanced digital and AI technologies into these standards, fostering industry growth. International collaboration in standardisation is essential, as container logistics is inherently global. China aims to contribute to these standards, promoting global compatibility and efficiency."*	

		Interviewee 6 (Line 346-348/ 360-361): *"I don't know if everyone is actively involved in the in the Chinese National Committee for standards, but you could understand the Chinese group or team has particular technological interests when they speak standardisation, for example in ISO TC 104 or everyone pulls their own direction. […] I think the Chinese want to get their yeah, so-called their standard be part of the ISO standards so that they can influence the rest to follow their standards."*	
	Governmental Subsidies	**Interviewee 1 (Line 165-173):** *Basically, you apply, and since it's considered a high-tech industry, the government approves the subsidy. The process is relatively easy, but the amount isn't very large—usually in the range of hundreds of thousands of RMB. For a shipping company, this amount is quite minimal. For example, we're currently working with the National Standards Committee (国标委 guobiaowei, National Standards Committee) on some system promotion projects. Their funding model is like this: for each task, they can provide up to about 500,000 RMB. If a company wants to collaborate with the government on a project, the government can contribute up to 500,000 RMB, but the rest of the costs must be covered by the company."*	

		Interviewee 6 (Line 389-395): *"I can show you that they don't call it a subsidised, but then they have this so-called R&D component in their tax filing.* *So, if they can prove that they have developed a new device, or something is new that they can actually quantify this as R&D cost.* *It means that this cost can be waived through tax.* *They don't get subsidised, but they get a lot of R&D costs with a tax waiver.* *So indirectly they get subsidised."* **Interviewee 2 (Line 189-191):** *"There are subsidies for research projects. In fact, container digitisation, we can apply for some research projects, but the group itself is not subsidised. Container itself, the smart container itself is not subsidised."* **Interviewee 3 (Line 378-379):** *"In IoT case, no, no, no, no, no, no, no, no, no, no, no, no, no, no money from a government. You know also money is a self, how to say self-born by the company."* **Interviewee 4 (Line 76-77):** *"I believe that container digitalisation cannot rely solely on government subsidies. It is more important to find a suitable business operating model."* **Interviewee 5 (Line 85-87):** *"Government support for digital logistics technologies comes through research projects rather than direct funding. This approach supports technological advancements while*	

		encouraging industry adoption through project-based funding." **Interviewee 7 (Line 380-388):** *"The first one is the digitisation of containers, which is always supported by the Chinese government. My understanding ah, not only the Chinese government support, including my understanding of Singapore, Malaysia, South Korea, they are very supportive, because we can see that through the development of intelligence can improve efficiency and security. This is no problem.* *Then, the second, why now intelligent container development is not as fast as we expected, a big reason is that governments support the development of intelligent containers, but the container industry did not get a penny of government subsidies, this is precisely the industry has been more entangled place."* **Interviewee 8 (Line 299-300/319-320/331-332):** *"Well, the government is kind of supporting, first, from policy side, they are kind of supporting it. But I don't think it's possible to talk about the topic... […] So, so it's really hard to judge whether it's possible or not, even when governments say we've done it…[…] You know, maybe, in the city like ours, maybe you know, maximum 3 to 5 companies, will get it. They would kind of do the horse racing."*	
	Technology Origins	**Interviewee 3 (Line 165-172/ 174-175):** *"we did some research and even in China we did research to select our*	Most of the interviewees emphasise the quality criterion to choose the technology

		manufacturing site. Finally, we selected the manufacturer's nearby Shanghai. *Not purely because of the location.* *But how to consider the facility?! Make it easy for management. Yeah, we must measure the quality of the manufacturing. Uh, to do the monitoring of the regulatory the compliance and so on. If the manufacturing is in overseas, then it means that we have to do a lot of travel and not easy for communication and to do this on-site check and the monitoring that's finally we selected the manufacturing factors. […] Quality and cost and how to say availability as well as the complexity of the management and control, yeah."* **Interviewee 4 (Line 54-58):** *"I believe that an open attitude should be maintained toward technology providers. As long as the technology meets functional requirements and offers high cost-effectiveness, there should be no restrictions on whether the provider is domestic or international. Currently, these technologies are relatively mature, and the differences between domestic and international technologies are minimal."* **Interviewee 5 (Line 77-79/ 100-102):** *"Regarding supplier preferences, China remains open to products from any country, provided they meet cost and efficiency criteria. For instance, Apple products and other international goods are widely used in China, reflecting*	providers. Same participants make the conclusion, that the devices are made in China. However, the Hapag- Lloyd and ZIM Line management preferred US, Swiss and Israeli technology providers.

		this openness. Our approach is open. We use products based on their reliability and suitability, regardless of origin. For example, many in China use Apple products, and our bags from Germany. What matters is the product's reliability and effectiveness." **Interviewee 6 (Line 190-194):** *"I think for what I understand so far, they have no restriction to say that they only use a Chinese tracking device.* *They can use anyone, any, any tracking device so long as meet their standard of reform.* *And yeah, but they themselves are very strong into this tracking device technology.* *As you know about Huawei, ZTE or another tech, I can't remember."* **Interviewee 7 (Line 180-189):** *"I think there may be some industries in China, there are different ways of saying this kind of, whether to use Chinese technology or American technology, right, and then whether it's developed country's technology or developing countries. They have different purposes and starting points and different interests. But in China, especially in my management of this container standardisation of this field, we form the same consensus, not only our water transport institute (Ministry of Transportation Institute of Water Transportation Science), including CIMC - they are the same. Our container needs a global use of*	

		the device. Which technology we use, with which products should be to follow international standards. We never from that in the end is the Chinese technology or American technology- to consider the accessibility of this equipment, adding more emphasis on the global use." **Interviewee 8 (Line 198-200):** *"Well, I think, for the electronic instruments, it's mostly made in China, but maybe the brands come from everywhere in the world. Whatever is applicable.* *For the application, it should be global because we can't confine ourselves within China."*	
	Standardisation Bodies	**Interviewee 3 (Line 361-362):** *"Then the main body is ISO, IEC and the UNCEFACT, and maybe also ITU."* **Interviewee 2 (Line 173-175):** *"We have our container standardization committee. We have a special organization to do this. These are the national committees that are interested in, they are interested in what the technology is."* **Interviewee 1 (Line 184/ 193-194):** *"We are part of an organization called COA. […] The second part is the National Standards Committee (国标委), which is China's National Standards Committee. Through this, we also participate in ISO activities."*	

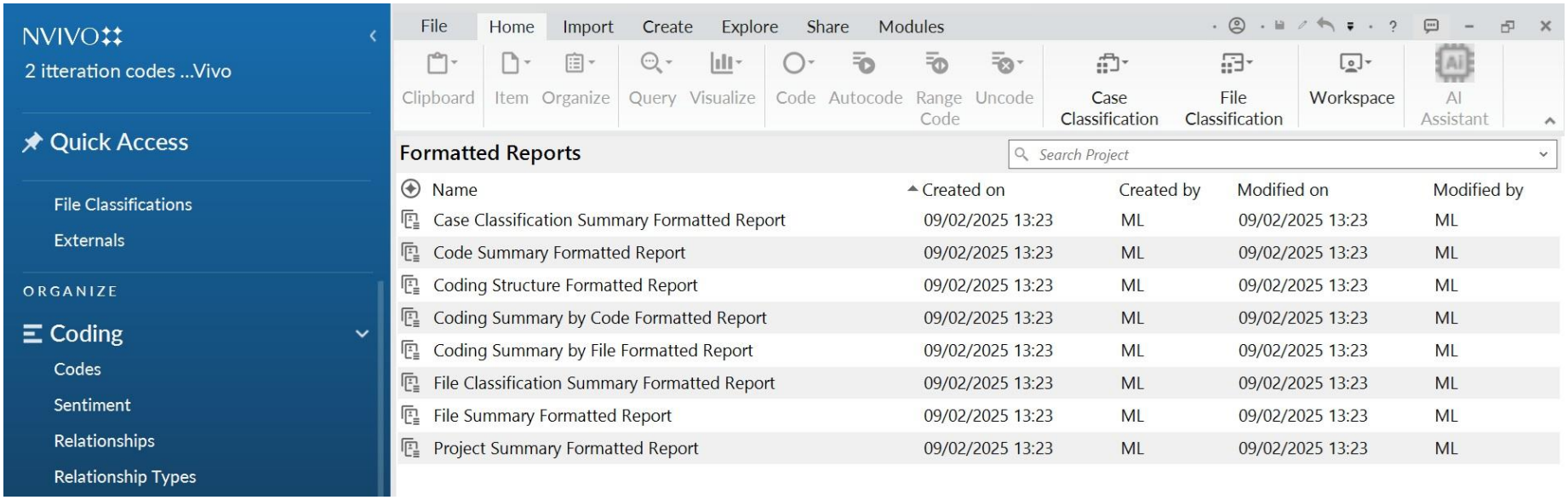
		Interviewee 4 (Line 70-71): *"We participate in the international ISO TC104 and China's container standardization organizations, primarily to contribute to and promote the development of relevant standards."* **Interviewee 5 (Line 112-116/ 120-123):** *"China participates in national, industry, and enterprise standards, with ISO being the most prominent. National standards are overseen by the National Standards Committee (SAC), and container standards are managed by the Ministry of Transport's Standardization Committee. China actively engages in ISO standards to promote advanced digital and AI technologies, fostering industry development. The Ministry of Transport participates in IMO standards related to maritime regulations. Containers fall under the jurisdiction of the National Container Standardization Committee. China aims to contribute to international standards, ensuring global compatibility and efficiency."* **Interviewee 7 (Line 325-328):** *"On this basis, we also have similar standards to foreign associations, such as the Chinese association for standards, China also has a number of related associations for standards, more industry kind of major enterprises, especially based on the commercial point of view, from the industry application point of view."*	

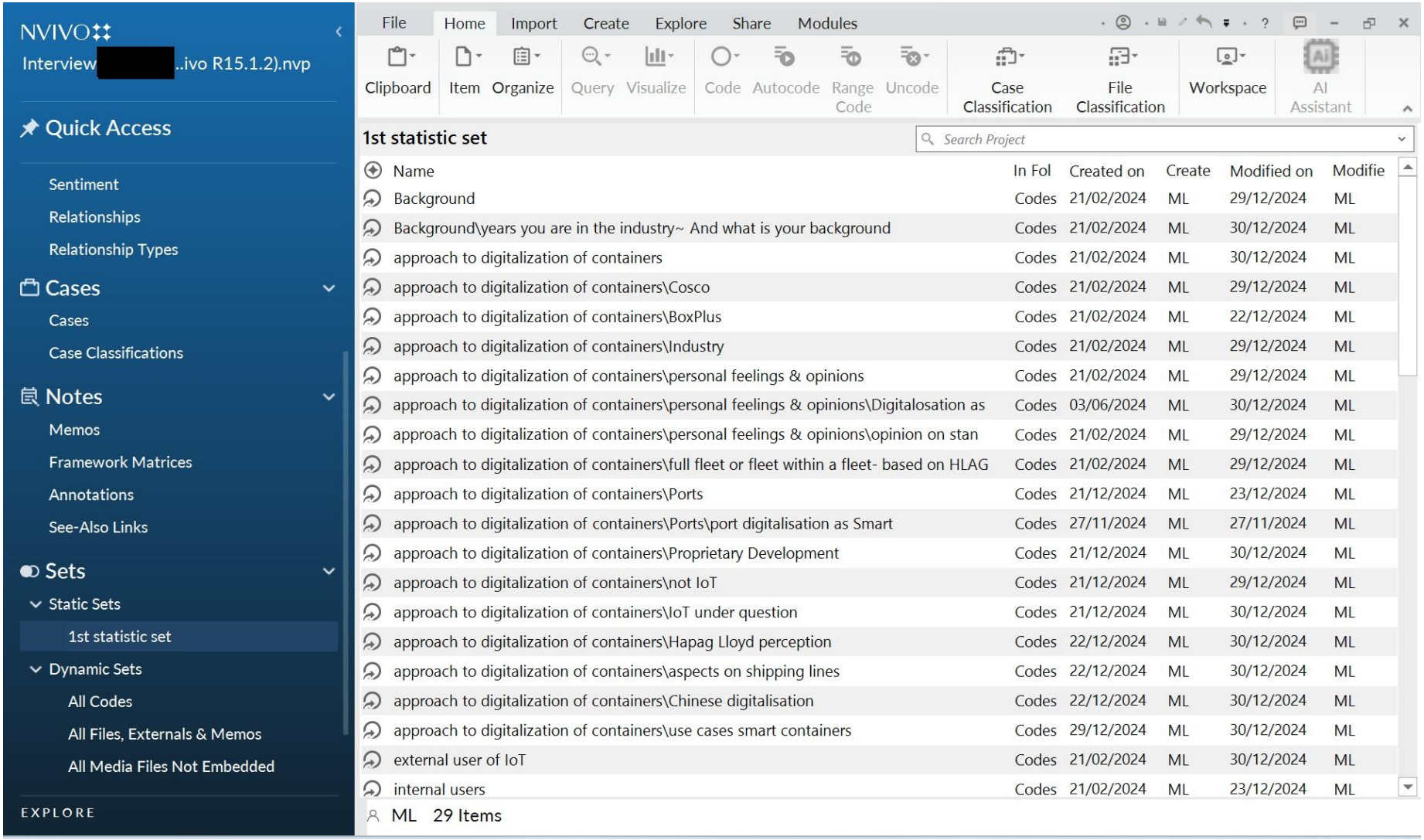
		Interviewee 8 (Line 269): *"yeah, we are always there with the ISO, but it's quite fluffy."*	Interviewee 8 speaks English in a closed private office, it felt like he allows him to express personal opinion.
RQ3: What is the Chinese perspective on data ownership and sharing in digitised supply chain?	Data Ownership & Use	**Interviewee 1 (Line 152-156/ 216-217/ 228-229):** *"I feel there's a concern about trade secrets in this area. So, at least for our company, that's the case. I won't speak for other companies, but all the technology we use—our IoT devices and systems—is developed in-house by our company. It's like that because of the involvement of trade secrets. […] This involves communication protocols from suppliers. Some suppliers are willing to open their interfaces to us, while others are not. […] We generally don't share it (data) unless the customer is willing to pay. We provide this as a paid service."* **Interviewee 2 (Line 140-141/146-152):** *": We don't use the data now; we collect the data and give it directly to the users. We do whatever the users ask us to do. […] We're not doing the sharing and processing of this digital ourselves, and I think it will be the same in the future. The data collected can be shared by him (the customer) within the scope of the license, for example, it is basically the shipping company that is doing this now, and after the company collects his data, it should share*	

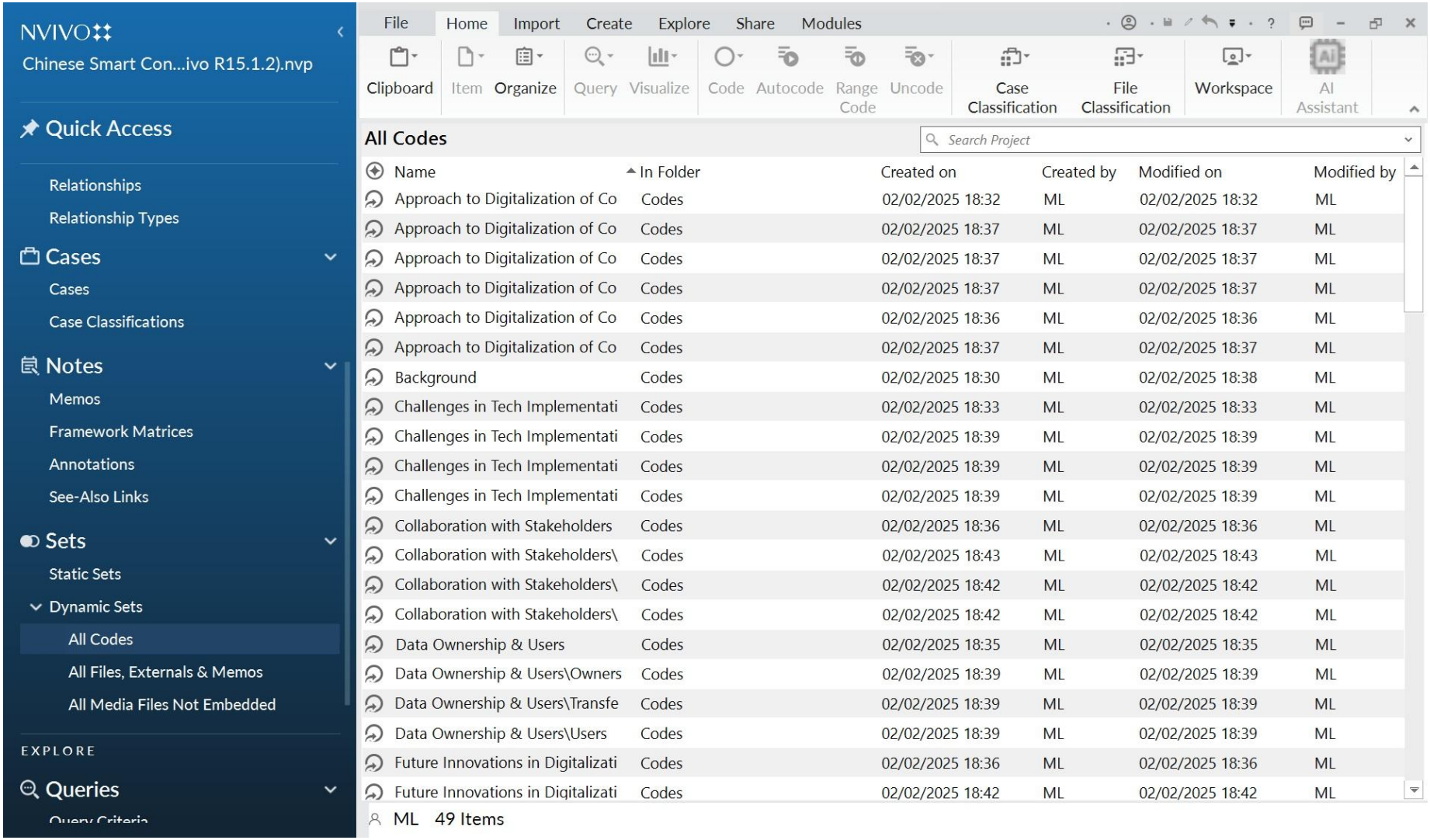
		it with his forwarder, his yard, etc., and with his cargo owner, right? So basically, in this area, it's the shipping companies or the owners themselves, the shipping companies, the logistics companies are doing this." **Interviewee 3 (Line 28-31/240-242/243-247):** *"The container digitalisation - I mean the IoT device, and the application at the platform to utilise the IT data as well as the shipping data together serve the shipping lines, internal users as well as the externals of the shipping lines, like the cargo owners, the forwarders. […] I usually call the internal users outside "the users", but it's true if we think that the staff of shipping lines or the cargo staff at cargo owner companies are the "internal users", yeah. […]* D*ata belongs to the end user. I mean who invested who purchased the Ibox from BoxPlus, he owns the data from Box Plus. Box Plus never controls or occupies the data. The data always belongs to Ibox customers. I mean the container owners or the shipping lines, or some logistics the service providers."* **Interviewee 6 (Line 293-294):** *"They (Chinese shipping lines) will share to if the if the shipper requests that they want to track their goods from point to point, then they will share with that particular shipper."* **Interviewee 7 (Line 293-298/302-303/227-230):** *"we also gave data to some companies, for example, COSCO; another one can be Maersk, we are trying to provide them with a third option, that is, we suggest that*	

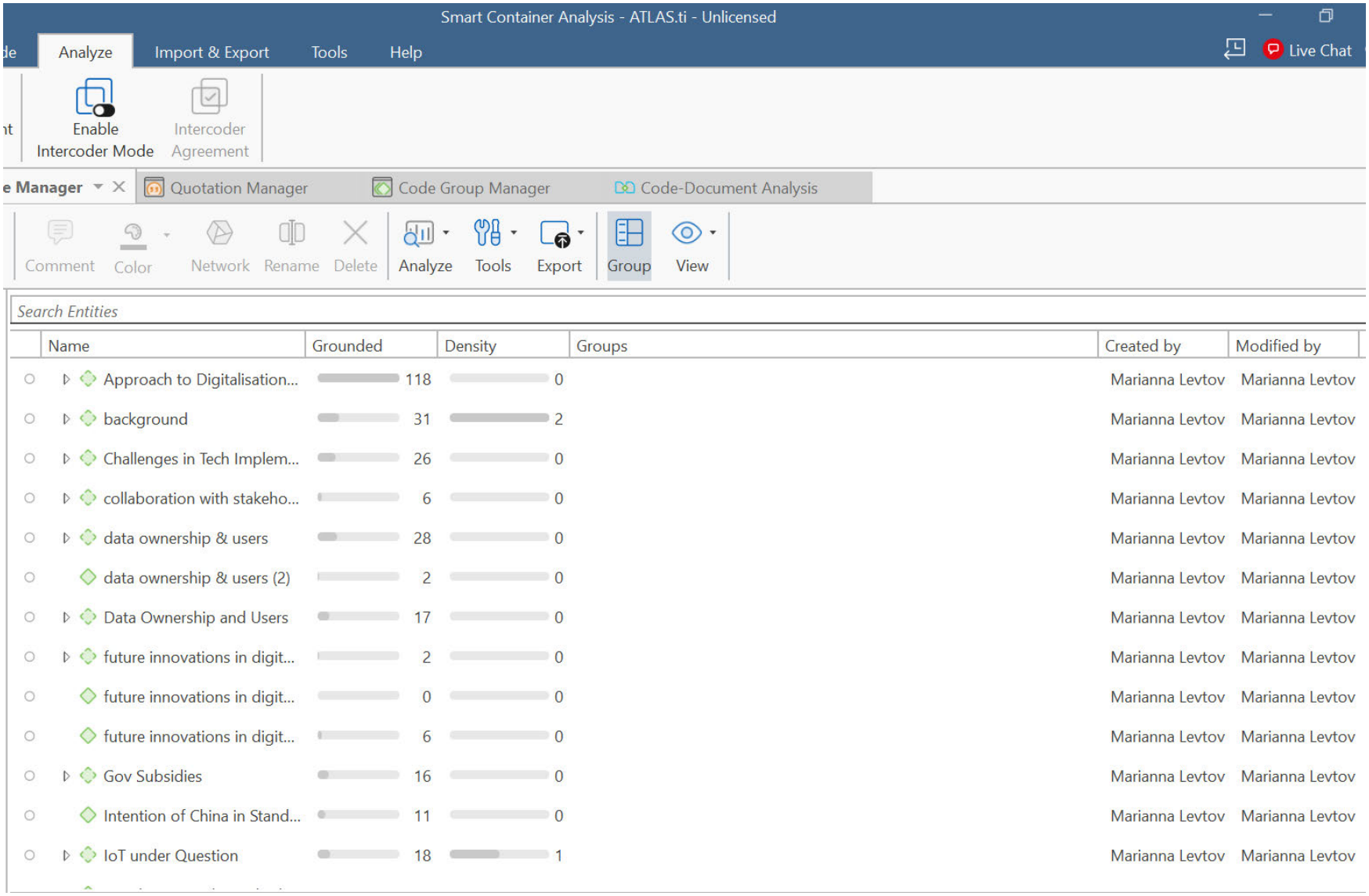
		they can be able to data kind of involved in the commercial part of the content of the elimination, and then involved in the simple transportation, the container status information, to achieve a basic sharing of such a case, so that they can share the data with other companies. In this way, they can realize a basic sharing of data. […] if you can share, it may be more conducive to the development of the whole intelligent container, industry intelligent transportation. […] maybe COSCO's system is developed by Chinese people themselves, maybe their company's information system is developed by their own company, but I have to comply with this kind of international data exchange agreement between the two companies, to be able to carry out the exchange of data." **Interviewee 8 (Line 67-68/ 73-75):** *"And on the other hand, even they (the leasing companies) are interested in getting it. They don't have access. They aren't getting an access to the data that they should not know. […] You don't need to know on our business because they know once you have the digital device onto their asset, then we have access to their products. And they don't want us to know their business."*	The claim of Interviewee 6 is his assumption and possible in the future as a common practice. It can be assumed, that Interviewee 7 speaks about the potential outcome of the data sharing agreement. He claimed later that the compliance with the international data exchange agreement is critical. Interviewee 8 said you to refer to the container lessors, who according to their clients should not have visibility on the assets in lease in order not to change the leasing conditions based on utilisation.

Appendix IV Selected Screenshots of the Interviews Coding and Intercoder Reliability, Nvivo and Atlas.ti Programmes




NVIVO
Interview [redacted]..ivo R15.1.2).nvp
Quick Access
Sentiment
Relationships
Relationship Types
Cases
Cases
Case Classifications
Notes
Memos
Framework Matrices
Annotations
See-Also Links
Sets
Static Sets
1st statistic set
Dynamic Sets
All Codes
All Files, Externals & Memos
All Media Files Not Embedded
EXPLORE
File
Home
Import
Create
Explore
Share
Modules
Clipboard
Item
Organize
Query
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AI Assistant
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Background\years you are in the industry~ And what is your background Codes 21/02/2024 ML 30/12/2024 ML
approach to digitalization of containers Codes 21/02/2024 ML 30/12/2024 ML
approach to digitalization of containers\Cosco Codes 21/02/2024 ML 29/12/2024 ML
approach to digitalization of containers\BoxPlus Codes 21/02/2024 ML 22/12/2024 ML
approach to digitalization of containers\Industry Codes 21/02/2024 ML 29/12/2024 ML
approach to digitalization of containers\personal feelings & opinions Codes 21/02/2024 ML 29/12/2024 ML
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approach to digitalization of containers\personal feelings & opinions\opinion on stan Codes 21/02/2024 ML 29/12/2024 ML
approach to digitalization of containers\full fleet or fleet within a fleet- based on HLAG Codes 21/02/2024 ML 29/12/2024 ML
approach to digitalization of containers\Ports Codes 21/12/2024 ML 23/12/2024 ML
approach to digitalization of containers\Ports\port digitalisation as Smart Codes 27/11/2024 ML 27/11/2024 ML
approach to digitalization of containers\Proprietary Development Codes 21/12/2024 ML 30/12/2024 ML
approach to digitalization of containers\not IoT Codes 21/12/2024 ML 29/12/2024 ML
approach to digitalization of containers\IoT under question Codes 21/12/2024 ML 30/12/2024 ML
approach to digitalization of containers\Hapag Lloyd perception Codes 22/12/2024 ML 30/12/2024 ML
approach to digitalization of containers\aspects on shipping lines Codes 22/12/2024 ML 30/12/2024 ML
approach to digitalization of containers\Chinese digitalisation Codes 22/12/2024 ML 30/12/2024 ML
approach to digitalization of containers\use cases smart containers Codes 29/12/2024 ML 30/12/2024 ML
external user of IoT Codes 21/02/2024 ML 30/12/2024 ML
internal users Codes 21/02/2024 ML 23/12/2024 ML
ML 29 Items


NVIVO
Chinese Smart Con...ivo R15.1.2).nvp
Quick Access
Relationships
Relationship Types
Cases
Cases
Case Classifications
Notes
Memos
Framework Matrices
Annotations
See-Also Links
Sets
Static Sets
Dynamic Sets
All Codes
All Files, Externals & Memos
All Media Files Not Embedded
EXPLORE
Queries
File
Home
Import
Create
Explore
Share
Modules
Clipboard
Item
Organize
Query
Visualize
Code
Autocode
Range Code
Uncode
Case Classification
File Classification
Workspace
AI Assistant
All Codes
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Challenges in Tech Implementati Codes 02/02/2025 18:39 ML 02/02/2025 18:39 ML
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Collaboration with Stakeholders Codes 02/02/2025 18:36 ML 02/02/2025 18:36 ML
Collaboration with Stakeholders\ Codes 02/02/2025 18:43 ML 02/02/2025 18:43 ML
Collaboration with Stakeholders\ Codes 02/02/2025 18:42 ML 02/02/2025 18:42 ML
Collaboration with Stakeholders\ Codes 02/02/2025 18:42 ML 02/02/2025 18:42 ML
Data Ownership & Users Codes 02/02/2025 18:35 ML 02/02/2025 18:35 ML
Data Ownership & Users\Owners Codes 02/02/2025 18:39 ML 02/02/2025 18:39 ML
Data Ownership & Users\Transfe Codes 02/02/2025 18:39 ML 02/02/2025 18:39 ML
Data Ownership & Users\Users Codes 02/02/2025 18:39 ML 02/02/2025 18:39 ML
Future Innovations in Digitalizati Codes 02/02/2025 18:36 ML 02/02/2025 18:36 ML
Future Innovations in Digitalizati Codes 02/02/2025 18:42 ML 02/02/2025 18:42 ML
ML 49 Items


Smart Container Analysis - ATLAS.ti - Unlicensed
Analyze
Import & Export
Tools
Help
Live Chat
Enable Intercoder Mode
Intercoder Agreement
Quotation Manager
Code Group Manager
Code-Document Analysis
Comment
Color
Network
Rename
Delete
Analyze
Tools
Export
Group
View
Search Entities
Name
Grounded
Density
Groups
Created by
Modified by
Approach to Digitalisation... 118 0 Marianna Levtov Marianna Levtov
background 31 2 Marianna Levtov Marianna Levtov
Challenges in Tech Implem... 26 0 Marianna Levtov Marianna Levtov
collaboration with stakeho... 6 0 Marianna Levtov Marianna Levtov
data ownership & users 28 0 Marianna Levtov Marianna Levtov
data ownership & users (2) 2 0 Marianna Levtov Marianna Levtov
Data Ownership and Users 17 0 Marianna Levtov Marianna Levtov
future innovations in digit... 2 0 Marianna Levtov Marianna Levtov
future innovations in digit... 0 0 Marianna Levtov Marianna Levtov
future innovations in digit... 6 0 Marianna Levtov Marianna Levtov
Gov Subsidies 16 0 Marianna Levtov Marianna Levtov
Intention of China in Stand... 11 0 Marianna Levtov Marianna Levtov
IoT under Question 18 1 Marianna Levtov Marianna Levtov

ID	Text Content
38:1	在华师大（华东师范大学）的物流院 （*物流管理学院）主要还是在从事关于港口物流方面的这个工作
38:2	智慧港口的智慧物流的这个研究呢
38:3	我始终(一直)感觉到就是港口的数字化是大势所趋 trend，因为传统的集装箱或者物流，实际上actually它是以这个物为基本basic的
38:4	将来随着这个物联网的发展，它的这个大的趋势（qu1shi4/ trend）肯定是朝着操作(cao1zuo4operation)数字化在走。那
38:5	很因为我的企业是上海港
38:6	各个环节的也在进行数字化的改造，这个包括它的整个装卸zhuangxie， load and unload的一个全过程。
38:7	从船运到开始吧，我们自动带来设备制度的来出国桥吊（crane）来卸下的箱子后，通过自动化的AGP把它运到了堆场（dui1chang3，con
38:8	我们讲, 就是讲人工智能的方向，在发展，alocation管理，包括装箱的自动化的，这个优化的，能够的都在超期。
38:9	而其他的码头在朝这方面发展。但是还不能说全部都在自动化，是逐步逐步的在朝着这个走。我们大家都感觉到自动化是一个发展的方向，这...
38:10	阿木斯开公司的上海港。就是一个基本的一个，那么他之间包含了三个层面，一个就是我们讲的那个设计的层面设上现在主要的是一个就是用...
38:11	一个就是云计算的方法，就是把这些大数据，如果这个有计算的方法，实现数据的高效的储存跟共享，通过数据的分析挖掘、建模、预测和预...
38:12	中国的集装箱也在本身物的部分，就是它的东西，一个结构下本身的部分，进行了一个数字化的改造。最典型的呢，就是我们已经在建立了中...

Intercoder Agreement for Project: Smart Container Analysis

Agreement Coefficient:	Krippendorff's c-Alpha-binary

Legend

Applied*	Number of times the code has been applied
Units*	Number of units* the code has been applied
Total Units*	Total number of units* across all selected documents
Total Coverage*	% Coverage within the selected documents

Coders

Marianna Levtov

YinYing Kong

Documents

Interviewee 5_sorted

Interviewee 1 Transcript 24.7.2024

Interviewee 2 13.09.2024

All Documents

Semantic Domain: Approach to Digitalisation of Containers

Code	Coder	Applied*	Units*	Total Units*	Total Coverage*
Approach to Digitalisation of Containers: Chinese vs German approaches					
	Marianna Levtov	6	564	21208	2.66%
	YinYing Kong	11	2199	21208	10.37%
Approach to Digitalisation of Containers: CIMC					
	Marianna Levtov	6	674	21208	3.18%
	YinYing Kong	17	2594	21208	12.23%
Approach to Digitalisation of Containers: method & applications					
	Marianna Levtov	20	1900	21208	8.96%
	YinYing Kong	28	3982	21208	18.78%
background: background to digitalisation					
	Marianna Levtov	1	15	21208	0.07%
	YinYing Kong	1	15	21208	0.07%
background: industrial area of experience					
	Marianna Levtov	1	86	21208	0.41%

	YinYing Kong	3	223	21208	1.05%
background: professional background-jobs					
	Marianna Levtov	3	66	21208	0.31%
	YinYing Kong	7	209	21208	0.99%
background: years in the industry					
	Marianna Levtov	2	57	21208	0.27%
	YinYing Kong	2	49	21208	0.23%
Challenges in Tech Implementation: past efforts					
	Marianna Levtov	3	305	21208	1.44%
	YinYing Kong	3	238	21208	1.12%
Challenges in Tech Implementation: Regulations & Standards (too much or lack of)					
	Marianna Levtov	2	181	21208	0.85%
	YinYing Kong	3	337	21208	1.59%
Challenges in Tech Implementation: scalability					
	Marianna Levtov	3	511	21208	2.41%
	YinYing Kong	6	917	21208	4.32%
collaboration with stakeholders: partnerships with ports					

	Marianna Levtov	1	141	21208	0.66%
	YinYing Kong	3	619	21208	2.92%
data ownership & users					
	Marianna Levtov	0	0	21208	0.00%
	YinYing Kong	2	152	21208	0.72%
data ownership & users (2)					
	Marianna Levtov	0	0	21208	0.00%
	YinYing Kong	2	152	21208	0.72%
Data Ownership and Users: users and owners					
	Marianna Levtov	0	0	21208	0.00%
	YinYing Kong	14	1369	21208	6.45%
future innovations in digitalisation connectivity					
	Marianna Levtov	1	151	21208	0.71%
	YinYing Kong	2	262	21208	1.24%
Gov Subsidies: examples with companies' names					
	Marianna Levtov	4	654	21208	3.08%
	YinYing Kong	3	654	21208	3.08%

Intention of China in Standardisation Process					
	Marianna Levtov	5	476	21208	2.24%
	YinYing Kong	5	476	21208	2.24%
IoT under Question: Adoption Challenge					
	Marianna Levtov	1	42	21208	0.20%
	YinYing Kong	0	0	21208	0.00%
IoT under Question: batter life					
	Marianna Levtov	0	0	21208	0.00%
	YinYing Kong	2	442	21208	2.08%
IoT under Question: RoI					
	Marianna Levtov	0	0	21208	0.00%
	YinYing Kong	5	917	21208	4.32%
Regulations and Standards					
	Marianna Levtov	1	61	21208	0.29%
	YinYing Kong	1	61	21208	0.29%
sharing					

	Marianna Levtov	9	868	21208	4.09%
	YinYing Kong	0	0	21208	0.00%
standardisation bodies: ISO					
	Marianna Levtov	5	295	21208	1.39%
	YinYing Kong	7	794	21208	3.74%
standardisation bodies: national body SAC					
	Marianna Levtov	3	358	21208	1.69%
	YinYing Kong	4	316	21208	1.49%
standardisation bodies: other organisations					
	Marianna Levtov	4	130	21208	0.61%
	YinYing Kong	0	0	21208	0.00%
technology origin: cost factor					
	Marianna Levtov	0	0	21208	0.00%
	YinYing Kong	2	437	21208	2.06%
technology origin: location-made in China					
	Marianna Levtov	3	194	21208	0.92%
	YinYing Kong	3	194	21208	0.92%

technology origin: quality					
	Marianna Levtov	0	0	21208	0.00%
	YinYing Kong	3	545	21208	2.57%
technology origin: supplier preferences					
	Marianna Levtov	1	145	21208	0.68%
	YinYing Kong	2	288	21208	1.36%
use cases smart container: what is smart container					
	Marianna Levtov	15	1596	21208	7.52%
	YinYing Kong	20	3358	21208	15.83%
users and owners					
	Marianna Levtov	4	380	21208	1.79%
	YinYing Kong	0	0	21208	0.00%

Reliability Coefficient

Krippendorff's c-Alpha-binary: 0.616