

# Optimizing Logistics Operations: an International Data Space (IDS) Inspired Multi-Sided Data Space Marketplace for Enhanced Data Sovereignty in the Logistics Industry

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**Abstract.** In the dynamic digital economy, the logistics sector grapples with data challenges. This paper proposes a transformative solution: the Multi-sided Data Space Marketplace. Leveraging technologies like the International Data Spaces (IDS), it aims to establish a secure, sovereign, and standardized environment for data exchange within logistics. Components such as Logistics Connector, Management, Broker, Identity Provider, and App Store form an interconnected ecosystem, enhancing efficiency and transparency. The paper outlines a systematic data access process, prioritizing transparency, security, and compliance. From registration to transaction confirmation using blockchain-based smart contracts, the solution emphasizes control for data owners. The Multi-sided Data Space Marketplace stands out for its logistics focus, data sovereignty, and App Store integration, setting it apart from generic data marketplaces. This research contributes to the discourse on data-driven innovation and interoperability, catalyzing change in logistics data management within the digital economy.

**Keywords:** Data space, data marketplace, international data spaces (IDS), data sovereignty.

## 1 Introduction

In the constantly changing realm of the digital economy, data emerges as the lifeblood propelling industries towards innovation and operational excellence. At the epicenter of this transformative wave stands the logistics sector, distinguished by its expansive and intricately woven supply chains [1]. However, amidst a staggering surge in data creation, projections surpassing the cumulative data of the past three decades, the logistics industry grapples with formidable challenges in its data-sharing practices [5]. The inadequacies inherent in current solutions, frequently characterized by compartmentalization and a lack of seamless integration, emphasize the pressing need for sophisticated data management paradigms [6].

As a critical facilitator of global trade and commerce, the logistics industry contends with multifaceted challenges in data-sharing paradigms [7]. Concerns ranging from security and privacy issues enveloping sensitive information to interoperability challenges arising from diverse systems and the entrenched resistance to change among stakeholders are formidable

hurdles. The absence of standardized formats and protocols for data sharing further exacerbates the intricacies of the landscape. In response to these challenges, this paper pivots towards the transformative potential embedded in large-scale data sharing, introducing a pioneering concept, the Multi-sided Data Space Marketplace, meticulously tailored for the intricacies of the logistics industry.

The essence of this research lies in its purpose: addressing existing challenges by formulating architecture principles specifically attuned to logistics-focused multi-sided data marketplaces. This pursuit stems from a broader rationale, charting a course toward an enriched understanding of the pivotal role and significance of such marketplaces within the unique context of the logistics domain. By strategically integrating principles from the International Data Space (IDS), a framework accentuating secure and sovereign data exchange, the approach aspires to lay a robust foundation for a paradigm shift in managing and sharing data within the intricate logistics ecosystem.

In pursuit of our objective, we employ a meticulously crafted methodological approach that combines insights from existing literature for a theoretical foundation with the active engagement of logistics experts to provide practical perspectives. This research extends beyond resolving unique challenges in logistics, aiming to contribute to a broader understanding of multi-sided data marketplaces. The proposed architecture (Figure 1) principles are positioned as a cornerstone for developing efficient, secure, and industry-specific data marketplace architectures, fostering innovation and interoperability across diverse sectors. The subsequent sections of this paper will intricately unpack related technologies, unveil a conceptual framework for the Multi-sided Data Space Marketplace, discuss its integration with International Data Spaces, and explore the transformative impact on the logistics sector.

## **2 Overview of relevant technologies and work**

Amidst the dynamic evolution of the digital economy, a myriad of pivotal technologies take center stage, fundamentally reshaping the operational dynamics of businesses and the functioning of economies. Cloud computing, characterized by its scalability and adaptability, has revolutionized the storage landscape, providing flexible solutions. Concurrently, big data technologies empower the processing of extensive datasets, extracting valuable insights that drive informed decision-making. Blockchain technology, with its decentralized and secure architecture, ensures transparent and tamper-resistant data transactions, contributing to robust data management and sharing practices [4]. The rise of edge computing is notable, facilitating data processing in proximity to the source, reducing latency, and augmenting real-time decision-making capabilities. The International Data Spaces (IDS) initiative introduces principles for secure and sovereign data exchange, emphasizing decentralized architectures, interoperability, security, and trustworthiness [18]. Crucial data standards, such as JSON and XML, foster interoperability, particularly significant in the logistics industry where seamless communication among disparate systems is paramount. Furthermore, emerging technologies like artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT) continue to redefine the technological landscape, contributing to the exponential growth of data [13]. This comprehensive understanding of technological foundations is essential for

contextualizing the proposed multi-sided data space marketplace tailored for the logistics industry, strategically addressing the industry's imperatives for secure, interoperable, and efficient data exchange within its vast and intricate logistics industry [3].

## **2.1 Multi-sided Data Marketplace (MSDM)**

A Multi-sided Data Marketplace (MSDM) is a digital platform that serves as an intermediary, connecting multiple groups of users involved in the exchange of data. Unlike traditional two-sided platforms that facilitate transactions between two user groups, MSDMs involve additional participants, known as complementary, who offer complementary services to the primary data buyers, sellers, and other types of participants [16]. The key actors in an MSDM typically include the platform owner, data providers, data consumers, and complements, forming a dynamic ecosystem. These platforms play a crucial role in promoting efficient and secure large-scale data transactions and fostering collaboration among diverse stakeholders in the data ecosystem [15]. In the context of the logistics business, it will serve as a central hub where logistics service providers, data providers, data consumers, and potential participants can interact, share, and trade crucial logistics-related data, such as information on shipping routes, transportation conditions, inventory levels, and other relevant logistics details.

## **2.2 International Data Space (IDS)**

The International Data Space (IDS) is a virtual data space that utilizes existing standards, technologies, and accepted governance models in the data economy [11]. It is designed to facilitate secure and standardized data exchange and linkage within a trusted business ecosystem. The IDS serves as a foundation for creating smart-service scenarios and enables innovative cross-company business processes, all while ensuring data sovereignty for the data owners.

# **3 A multi-sided data space marketplace for the logistics industry**

Crucial for fostering collaboration and efficiency in the rapidly growing and complex logistics ecosystem, a Multi-sided Data Space Marketplace addresses the challenges of the vast geographical expanse and diverse supply chains by providing a centralized platform for seamless exchange and access to critical logistics data [10]. This marketplace (Figure 3) enables real-time sharing of information on shipping routes, inventory levels, and transportation conditions, allowing companies to optimize operations, reduce costs, and enhance overall supply chain management. In the rapidly evolving and competitive logistics market, a Multi-sided Data Space Marketplace plays a pivotal role in promoting innovation, streamlining processes, and contributing to economic growth by improving the effectiveness of supply chain infrastructure. To harness this transformative potential, our exploration incorporates principles from the International Data Spaces (IDS).

## **3.1 Conceptual Framework: Multi-Sided Data Marketplace**

A multi-sided data marketplace acts as a dynamic hub for data exchange within the logistics ecosystem, involving manufacturers, suppliers, distributors, and various participants like data sellers, buyers, and intermediaries. It establishes an ecosystem where entities can contribute,

sell, or purchase data assets, enabling data sellers to monetize datasets and offering data buyers access to a diverse range of datasets for enhanced analytics. Intermediaries play a crucial role in simplifying transactions and providing services such as data quality assurance, integration, and analytics. However, challenges arise, including privacy and security concerns demanding robust compliance measures with data protection regulations, as well as the need for standardization to address variations in dataset formats and structures for effective integration. Trust-building and quality assurance are emphasized for transparent and reliable data exchange within this marketplace [10].

The concept of multi-sided data marketplaces has found application in various industries, such as healthcare, where anonymized patient data is shared for research, and the retail sector, which utilizes consumer behavior data for targeted marketing and product development [12]. Technological advancements, including blockchain, are employed to enhance security and transparency in transactions. As the landscape evolves, future trends suggest deeper integration with artificial intelligence for automated analysis and the emergence of decentralized data marketplaces leveraging blockchain for increased security and transparency.

### **3.2 Integration with International Data Spaces (IDS)**

Representing a standards-based paradigm for data sovereignty and secure exchange, IDS can be pivotal for constructing reliable data ecosystems in the logistics industry [17]. By aligning with IDS principles, the envisioned multi-sided data space marketplace aims to address concerns about data security, privacy, and integrity among heterogeneous stakeholders, fostering a conducive environment for data interchange. The integration with IDS signifies a significant progression towards impregnable and sovereign data transactions, anchored in data sovereignty and interoperability principles. This framework introduces secure data spaces and connectors, allowing entities to retain control over their data while enabling standardized and secure communication across disparate data spaces [14]. Particularly crucial for inter-organizational collaborations, this approach provides a secure framework for data sharing and exchange.

The amalgamation with IDS offers manifold advantages, including trusted paradigms for global data exchange, enhancing transparency and efficiency in supply chain management, and providing a secure conduit for data sharing in healthcare [7]. However, challenges such as regulatory conformity and technical accommodations must be carefully considered in the integration process. Despite these challenges, the integration with IDS contributes significantly to global efforts aimed at standardizing data exchange practices, with various industries, including automotive and healthcare, showing interest in harnessing IDS for secure and standardized data exchange, shaping the trajectory of future data collaboration [17].

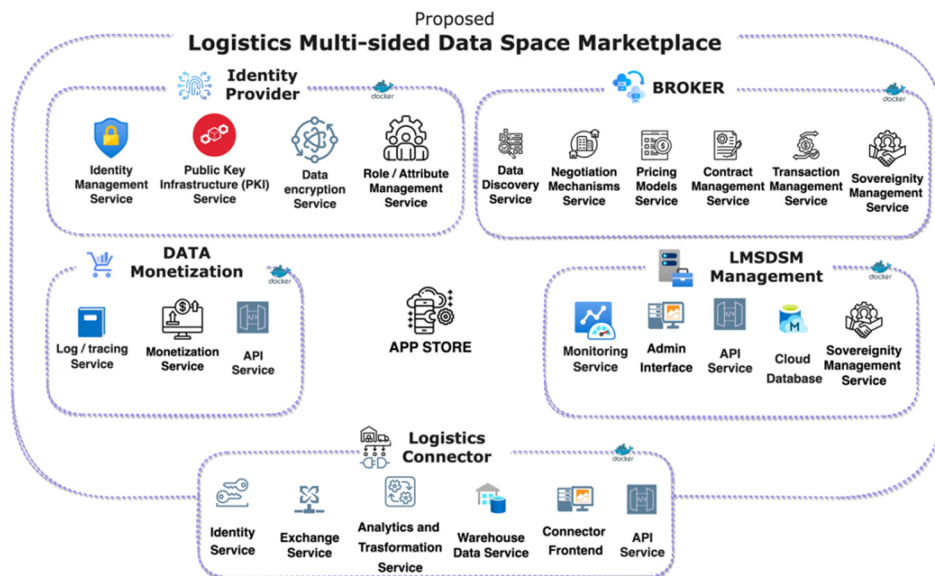
### **3.3 Current Challenges in Logistics Data Exchange**

The logistics industry faces significant challenges in data sharing, with security and privacy concerns being paramount. The exposure of sensitive information, such as shipment details and customer data, poses a substantial problem, necessitating the critical balance of data security and privacy [7]. Interoperability issues compound the situation, arising from the diverse systems and standards employed by different stakeholders in the logistics ecosystem, making seamless data exchange challenging [3]. Resistance to change, especially rooted in

concerns about disrupting established workflows and financial constraints for implementing advanced data-sharing technologies, further complicates the landscape. Trust-related issues, encompassing fears of data misuse and reliability concerns, hinder effective collaboration through data sharing [8].

Moreover, regulatory compliance adds complexity, requiring the logistics sector to navigate data protection and privacy regulations while promoting efficient data-sharing practices. The industry also grapples with challenges related to data quality, limited supply chain visibility, cybersecurity threats, and ownership concerns surrounding shared data, creating a multifaceted landscape that demands collaborative efforts, technological advancements, and robust governance frameworks tailored to the intricacies of logistics data sharing. Addressing these challenges is crucial for enhancing data-sharing practices within the logistics industry.

## 4 Proposed solution



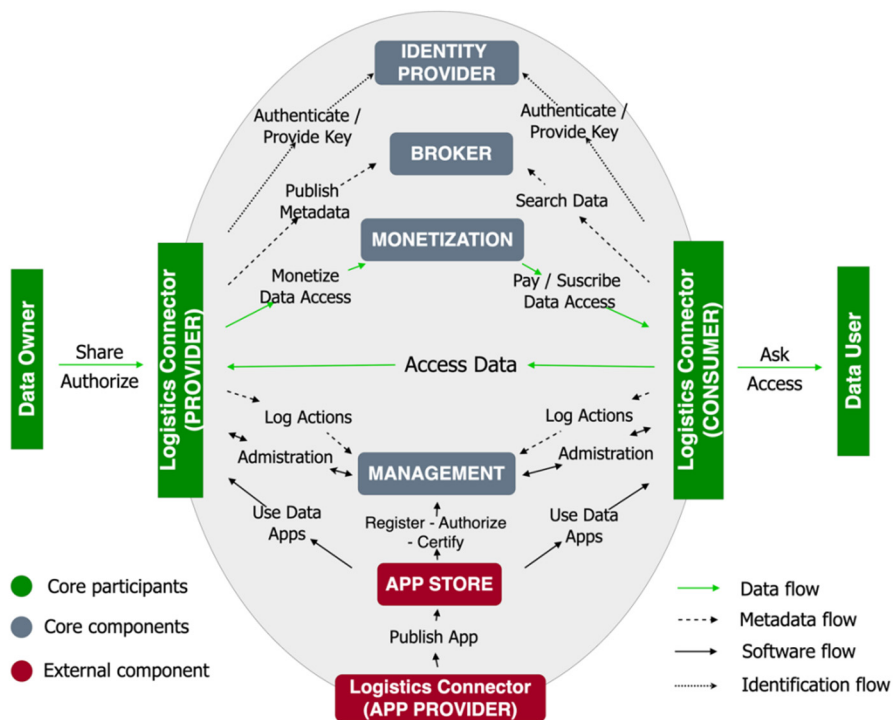
**Figure 1:** The proposed solution for the logistics industry data exchange and collaboration.

The proposed solution for the Multi-sided Data Space Marketplace in the logistics business (Figure 1) aims to create a comprehensive and efficient platform for the exchange of logistics-related data among various stakeholders. The solution is structured around several key components, each serving a specific role in facilitating data sharing and access to solve all the challenges mentioned previously.

At the heart of this infrastructure is the Logistics Connector, serving as a pivotal link between diverse logistics systems. This connector facilitates seamless integration through the use of APIs and messaging protocols, ensuring real-time data exchange between entities and the other components in the proposed solution.

The Management component takes charge of governance and compliance. It oversees user access, monitors compliance with regulations, and provides insights into the overall functioning of the infrastructure. The connection between the data marketplace and management guarantees a secure and well-regulated environment for participants.

Facilitating the actual data transactions, the Broker component is intricately connected to the Data Marketplace. Utilizing the marketplace, the Broker matches data buyers with sellers, employing algorithms for automated negotiation, dynamic pricing, and recommendation engines. This connection enhances the efficiency of data transactions within the proposed solution.



**Figure 2:** Information flow within the proposed multi-sided Data space marketplace for logistics.

To ensure secure access and participant authentication, the infrastructure is integrated with the Identity Provider. This integration enhances the overall security of the solution, managing participant authentication, and authorization, and providing robust access control measures.

Expanding the functionality of the solution, the App Store is added to the solution. This integration enables participants to seamlessly access and integrate third-party applications, enhancing the overall capabilities of the logistics data ecosystem.

Financial transactions are managed through the connection between the Data Marketplace and the Broker. Post data transactions, the marketplace handles payment processing and ensures proper settlement between the involved parties, providing a transparent and efficient financial infrastructure.

These connections are established through standardized communication protocols, RESTful APIs, messaging queues, and event-driven architectures. The proposed solution is the central hub where these connections converge, creating a cohesive and interoperable platform for logistics data transactions. This integrated ecosystem fosters improved efficiency, collaboration, and transparency within the logistics business.

#### **4.1 Data access and sharing**

The access and sharing of data within the Multi-sided Data Space Marketplace for logistics are orchestrated through a systematic and interconnected process (Figure 2). The transparency, security, and compliance embedded in each step contribute to the creation of a reliable and efficient ecosystem for managing logistics data.

##### **4.1.1 DATA SHARING**

###### **(1) Data Provider Registration**

Data providers initiate the process by formalizing their presence on the platform through registration. The Management component and the Identity provider oversee this process, ensuring the authentication of participants to guarantee secure access to the marketplace.

###### **(2) Data Listing on Marketplace**

Subsequently, registered data providers proceed to list their datasets on the Data Space Marketplace. This step involves the meticulous creation of a data catalog, encompassing critical metadata, pricing details, and other pertinent information. The Logistics Connector assumes a pivotal role in this phase, ensuring the seamless integration of the data into the marketplace with adherence to requisite formatting standards.

###### **(3) Broker Matching**

The Broker component intervenes when a data buyer expresses interest in a particular dataset. Leveraging sophisticated matching algorithms, the Broker facilitates connections between the buyer and suitable data providers, overseeing negotiation processes and formalizing agreements.

###### **(4) Smart Contracts and Transaction Confirmation**

Smart contracts, underpinned by blockchain technology, are employed to automate and secure transaction processes. Upon the mutual agreement of terms, the Data Space Marketplace orchestrates the confirmation of the transaction, certifying that the data is ready for access.

##### **4.1.2 DATA ACCESS**

###### **(1) Participant Authentication**

Rigorous authentication through the Identity Provider is mandated for data buyers to access the purchased datasets. This step is instrumental in ensuring that only duly authorized participants gain access to the acquired data.

###### **(2) Payment Processing**

The data marketplace and broker component assume responsibility for managing financial transactions. Following the confirmation of data access, the broker meticulously oversees the payment process, guaranteeing equitable compensation for data providers.

### (3) Data Retrieval

The Logistics Connector comes into play to facilitate the seamless retrieval of data and manage the technical intricacies of data transfer. This encompasses real-time synchronization to ensure that the data provided is the latest and most accurate version available.

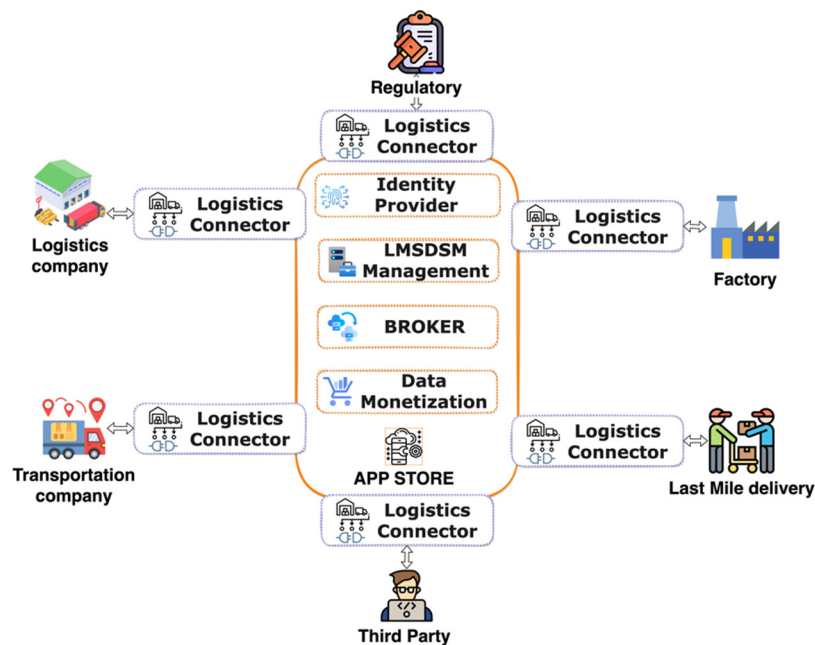
### (4) Integration with Applications

When third-party applications from the App Store are involved, the Data Marketplace facilitates their integration. The Logistics Connector ensures a harmonious and compatible interaction between the purchased data and the integrated applications.

### (5) Monitoring and Compliance

The Management component continually monitors data access to ensure strict adherence to regulatory frameworks and marketplace policies. This encompasses the tracking of usage patterns, management of access controls, and the generation of comprehensive reports for stakeholders.

## 4.2 Flow of Information and Sovereignty



**Figure 3:** Multi-sided Data space marketplace with some participants.

The flow of information in this proposed solution (Figure 2) adheres to a well-defined structure, ensuring that data transactions are transparent and compliant. Each step, from registration to data access, is recorded, and stakeholders are informed through the Management component. Additionally, data sovereignty is preserved by implementing secure user authentication through the Identity Provider. This ensures that access to sensitive information is restricted to authorized entities, safeguarding the privacy and control of data



owners. Moreover, the utilization of blockchain-based smart contracts in the transaction confirmation process adds an extra layer of security and transparency, assuring stakeholders of the integrity of the data transactions. The interconnected nature of these processes is orchestrated with a commitment to data sovereignty, emphasizing control, security, and compliance within the Multi-sided Data Space Marketplace for logistics.

### **4.3 Comparison with existing solutions**

The Multi-sided Data Space Marketplace for logistics introduces a groundbreaking paradigm in the realm of data marketplaces, particularly within the logistics industry. Unlike traditional data marketplaces, which may offer generic data exchange platforms, this innovative solution is specifically tailored to address the unique challenges and requirements of the logistics sector. This differentiation is crucial, as logistics operations involve intricate and dynamic data sets that demand a specialized approach [8].

The Multi-sided Data Space Marketplace presents a novel departure from conventional data marketplace models, introducing a comprehensive ecosystem connecting various stakeholders in the logistics domain. Unlike existing solutions that focus on generic data transactions, this platform integrates components such as the App Store, Identity Provider, and Broker to create a sophisticated and interconnected logistics data infrastructure. Notably, its emphasis on data sovereignty and control by the data owner distinguishes it from other marketplaces, aligning with the increasing importance of data ownership and privacy concerns. This commitment to providing data owners with control over their information addresses critical issues related to data ownership, setting it apart in an era where data privacy is paramount [2], [9].

The Multi-sided Data Space Marketplace is a tailored solution catering to the unique needs of the logistics industry. Its integration of an App Store introduces innovation by allowing logistics professionals to customize and enhance their data analytics capabilities through third-party applications, a feature absent in traditional marketplaces. This specialized approach holds particular significance for the logistics sector, offering a transformative force that addresses emerging challenges and introduces a new era of data collaboration. By prioritizing data sovereignty, interoperability, and customization, the Multi-sided Data Space Marketplace emerges as a pivotal solution for the rapidly evolving and technologically advanced logistics industry.

## **5 Conclusion**

This paper introduces the Multi-sided Data Space Marketplace (Figure 1) as a transformative solution to pressing challenges in the logistics industry. Focused on enhancing data sharing efficiency, interoperability, and security, the solution aligns with International Data Spaces (IDS) principles, creating a secure, sovereign, standardized environment. Key components (Figure 2), including the Logistics Connector, Management, Broker, Identity Provider, and App Store, form an interconnected ecosystem designed for efficiency, collaboration, and transparency. The process, from data provider registration to data transaction confirmation, prioritizes data owner control, security, and compliance.

Compared to existing solutions, the Multi-sided Data Space Marketplace is a specialized and innovative platform tailored to the logistics industry's unique challenges. Emphasizing data

sovereignty and integration with an App Store, it addresses current issues and anticipates future trends.

This research contributes to the discourse on data-driven innovation and interoperability, acting as a catalyst for change within the logistics sector. By leveraging advanced technologies, the proposed solution responds to existing challenges and proactively shapes the future of logistics data management, inspiring further exploration and implementation in the dynamic intersection of logistics and the digital economy.

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## References

- [1] Junjie Hong, Binglian Liu. (2007). Logistics Development in China: A Provider Perspective. *Transportation Journal* 1 April 2007; 46 (2): 55–65. doi: 10.2307/20713671.
- [2] Shawn P. Daly, Lindsay X. Cui. E-logistics in China: basic problems, manageable concerns and intractable solutions. *Industrial Marketing Management*, Volume 32, Pages 235-242, ISSN 0019-8501, doi: 10.1016/S0019-8501(02)00267-5.
- [3] C. Yan and Q. Li-li, "The Research of Universal Data Mining Model SYSTEM BASED on Logistics Data Warehouse and Application," 2007 International Conference on Management Science and Engineering, Harbin, China, 2007, pp. 280-285, doi: 10.1109/ICMSE.2007.4421861.
- [4] Chao Fu, Shize Zhang, Qiang Cui, Dedi Huang, Yaping Chen, and Zhiqing Huang "SSCDS: a secure supply chain data sharing scheme based on blockchain and IPFS", Proc. SPIE 12814, Third International Conference on Green Communication, Network, and Internet of Things (CNIoT 2023), 128141B (20 October 2023); doi: 10.1117/12.3010430
- [5] Xinchun Wang, Dan Zhang. Research on the Impact of Big Data on the Development of Supply Chain Logistics Management. *E3S Web Conf.* 251 01039 (2021). doi: 10.1051/e3sconf/202125101039.
- [6] Tommaso Isernia, Giovanni Leone, Rocco Pierri, and Francesco Soldovieri, "Role of support information and zero locations in phase retrieval by a quadratic approach," *J. Opt. Soc. Am. A* 16, 1845-1856 (1999). Doi: 10.1364/JOSAA.16.001845.
- [7] Otto, B., Hompel, M.t., Wrobel, S. (2019). *International Data Spaces*. In: Neugebauer, R. (eds) *Digital Transformation*. Springer Vieweg, Berlin, Heidelberg. Doi: 10.1007/978-3-662-58134-6\_8.
- [8] Xing, W., Elhabian, S. Y., Keshavarzadeh, V., and Kirby, R. M. (March 4, 2020). "Shared-Gaussian Process: Learning Interpretable Shared Hidden Structure Across Data Spaces for Design Space Analysis and Exploration." *ASME. J. Mech. Des.* August 2020; 142(8): 081707. Doi: 10.1115/1.4046074.
- [9] Hummel, P., Braun, M., Tretter, M., & Dabrock, P. (2021). Data sovereignty: A review. *Big Data & Society*, 8(1). Doi: 10.1177/2053951720982012.
- [10] Fraunhofer AISEC. 2022. *IDS Trusted Connector*. An edge platform for privacy-preserving data processing and trusted execution. <https://industrial-data-space.github.io/trusted-connector-documentation/docs/overview>.

- [11] P. H. Rettore, G. Maia, L. A. Villas and A. A. F. Loureiro, "Vehicular Data Space: The Data Point of View," in *IEEE Communications Surveys & Tutorials*, vol. 21, no. 3, pp. 2392-2418, thirdquarter 2019, doi: 10.1109/COMST.2019.2911906.
- [12] Steinbuss S. & al. (2019): Blockchain Technology in IDS. International Data Spaces Association. Doi: 10.5281/zenodo.5675962.
- [13] Usländer, T. (2022): Data Sovereignty – Requirements Analysis of Manufacturing Use Cases. International Data Spaces Association. Doi: 10.5281/zenodo.6668994.
- [14] iSHARE, Trust framework for Data Spaces, 2022. URL: <https://ishare.eu/>.
- [15] Otto, B., Jarke, M. Designing a multi-sided data platform: findings from the International Data Spaces case. *Electron Markets* 29, 561–580 (2019). Doi: 10.1007/s12525-019-00362-x.
- [16] Bharosa, N., Janssen, M., Klievink, B., & Tan, Y-h (2013). Developing multi-sided platforms for public-private information sharing. In *Proceedings of the 14th Annual International Conference on Digital Government Research* (pp. 146–155). Doi: 10.1145/2479724.2479747.
- [17] Ghazawneh, A., & Henfridsson, O. (2015). A paradigmatic analysis of digital application marketplaces. *Journal of Information Technology*, 30(3), 198–208. Doi: 10.1057/jit.2015.16.
- [18] Weber, K., Otto, B., & Österle, H. (2009). One size does not fit all: a contingency approach to data governance. *Journal of Data and Information Quality*, 1(1), 1–27. Doi: 10.1145/1515693.1515696.