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Logistics 4.0 Maturity Level Protocol for Logistics Service Provider

Contents

Editorial Board and Disclaimer

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1 Executive Summary

New challenges are constantly arising in supply chain logistics which calls for innovation. Emergence of new technologies are constantly creating disruptions which opens new business opportunities. Logistics 4.0 is a concept that helps in leveraging the power of these technologies to benefit the whole ecosystem and drive revenues. To adapt to these changing times, companies need to move towards digitalization. While the leading market players are busy innovating, the SMEs have also managed to enter the ground to make their processes smart and their decisions intelligent.

The term Logistics 4.0 is focusing not only on the logistical processes in the logistics services providers and manufacturing sector, it embraces technological use cases enhancing the full value-creation process of turning raw material into sellable goods and it does not stop there. A successful transformation requires the solutions, realized through technologies, to be aligned with both the focus on the unique situation of the organization as well as with its culture and specific qualifications. The goal of Logistics 4.0 of becoming more flexible in the interaction with stakeholders and their shifting demands is required in the current situation while increasing resistance against unplanned disruptions.

This document is a guideline for every logistics services providers company to implement Logistics 4.0. It contains a stepwise approach to attain higher levels of digital maturity. By addressing the current challenges and analysing the opportunities of Logistics 4.0, a roadmap has been developed for logistics services providers companies along with specific use cases. Additionally, a tool for self-assessment is provided for businesses to measure their current individual digital maturity regarding Logistics 4.0, to plan the company-specific roadmap and define value-adding pilot projects.

2 Introduction – Project Background

2.1 Motivation

The global pandemic, chip crisis, disrupted logistics networks and increasing compliance requirements pose unforeseeable challenges to global enterprises. Uncertainties and delays in global supply chains accumulate while consumer expectations on what can be done online and what can be delivered on short notice are steadily increasing. The resources that are not scarce or insufficient to meet the customer demand cannot be miraculously generated through digitalization and connectivity in global value networks. Still, digital capabilities help companies to create comprehensive transparency and react faster and better in uncertain and dynamic environments. The term *Logistics 4.0* describes the impact of Industry 4.0 on logistics and the interaction of Industry 4.0 technologies and paradigms with the cross-functional and inter-company functions and processes of logistics.

The digital connectivity and close integration of processes, assets, and entities in the supply chain, such as producers, vendors, warehouses, transportation companies, distribution centres, retailers and customers offers great potential for all stakeholders. Companies that continue to build their digital capabilities in logistics can, for example, minimize their costs through stronger collaboration, transparency about the status quo, increased automation, and higher efficiency of processes. On the other hand, companies have the opportunity to enhance customer satisfaction through increased delivery reliability, quality, flexibility and explore growth opportunities through new digital business models.

2.2 Project Scope

To help its HKSMEs companies to implement Logistics 4.0 and build stronger digital capabilities in the area of logistics, the Hong Kong Shippers' Council, together with the Hong Kong Productivity Council (HKPC) and international partners, initiated the project "Towards Logistics 4.0 - Preparing for The Next Stage Of Logistics In Hong Kong".

During the three major project phases from 2019 to 2022, more than 100 HKSMEs companies of the Shippers Council were surveyed on their logistics services and processes. In total, assessments with 22 selected pilot companies that fall into the categories of manufacturing companies with trading activities, trading companies without manufacturing activities, sea freight forwarder companies as well as cross border logistics companies were conducted to determine the status quo of logistics processes. Based on the gained insights, extensive roadmaps were developed to support companies in shaping the transformation to Logistics 4.0 and taking steps towards value addition. Furthermore, international

conferences and seminars were held to share insights on the value, application fields and business model innovations of Logistics 4.0.

2.3 Introduction of the Entities

Shippers Council

The Hong Kong Shippers Council was established in 1967. The council consists of 15 trade associations and serves to protect and promote the interests of Hong Kong exporters and importers, traders and manufacturers in any issues relating to the transportation of merchandise by sea, land, and air. The Shippers Council represents Hong Kong shippers globally and shapes the regulatory environment on issues relating to the shipping and transportation of goods on a local, regional, and global level together with other regional and international organization.

Hong Kong Productivity Council (HKPC)

The Hong Kong Productivity Council (HKPC), established in 1967, is a multidisciplinary organization, which is tasked to promote productivity excellence in the Hong Kong industry sector and assist Hong Kong enterprises through the introduction of advanced technologies and innovative service offerings. HKPC focuses on topics such as IoT, big data analytics, AI, robotics, digital manufacturing, etc., to help companies to increase competitiveness in local and international markets, improve productivity, and reduce operating costs.

Fraunhofer IPT

The Fraunhofer society is a German research organization and the largest organization of applied research in Europe. Fraunhofer IPT, located in Aachen, is part of the largest cluster of production technology institutes in Europe. This cluster is formed together with renowned institutes at the RWTH Aachen Campus and is conducting research on providing connected, adaptive production solutions in Industry 4.0 for companies of all sizes.

INC Invention Center

INC Invention Center is a spin-off of Fraunhofer IPT and bundles know-how from various Fraunhofer and research institutes. It is headquartered at RWTH Aachen Campus and offers professional consulting and implementation services by helping companies become leading innovators through profound expertise in the fields of Industry 4.0, AI in production, sustainability as well as innovation and technology management.

In the project at hand, INC Invention Center as implementation agent was responsible for conducting the cross-industry survey of companies as well as the assessments of the selected pilot companies together with the HKPC. Based on results, INC developed roadmaps to provide Hong Kong companies with actionable recommendations for their transformation to Logistics 4.0.

3 Introduction to Logistics 4.0 & Industry 4.0

3.1 Industry 4.0

Industry 4.0 is hailed as the fourth industrial revolution and constitutes a fundamental transformation of industrial value creation through the emergence of flexible, highly dynamic and globally connected value networks. For companies, the vision of industry 4.0 is to transform into a learning, agile enterprise that can adapt to volatile markets and dynamic environments and respond quickly to changing conditions. Industry 4.0 goes beyond automation as it enables the transmission, processing and use of mass data.

For enterprises, Industry 4.0 offers new opportunities to find value and capture it. Either companies can increase growth and revenue by introducing data-based business models, developing smart products or offering data-driven services. On the other hand, costs can be reduced by increasing efficiency and flexibility, saving time or improving quality of products and services. Hence, industry 4.0 is not an end in itself, but enables companies to grow or improve operations supported by modern information and communication technology (ICT).

Technology Enablers of Industry 4.0

From a technology perspective, the revolutionary aspect lies in the ability of multimodal ad-hoc networking for communication and information exchange of people and cyber-physical systems in real time. Data consistency along the value chain is enabled by the so-called “single source of truth” concept, which essentially describes the practice of structuring data and information in a redundance-free manner to circumvent contradicting data sets and ensure a reliable basis for data analytics applications. The integration of modern sensor technologies and ICT in physical assets, the interconnection of people, systems and devices via the Internet of Things (IoT), analytics capabilities and a variety of assistance systems to provide data-based insights to users are the main technology enablers and central contributors to bringing intelligence to the full value chain.

3.2 Logistics 4.0

The connection of people and cyber-physical systems for the communication and exchange of data as well as the progression of the internet from an information source to the Internet of Things and Services also has significant consequences for the logistics sector. The technological enablers of Industry 4.0 offer great potential in terms of transparency, speed, flexibility and manageability of logistics processes and are transforming the logistics sector toward the next stage of evolution: Logistics 4.0.

For logistics, digitalization enables an interactive flexibilization of business models, processes and partner networks. In a narrower sense, Logistics 4.0 encompasses the linking and integration of logistics processes inside and outside companies and production facilities along the entire value chain to create decentralized and real-time logistics networks. Ultimately, Logistics 4.0 is not only about creating a digital supply chain for individual companies, but also about connecting various value and supply chains of global company networks.

All elements in the network, such as IT systems, humans, assets, and goods are connected via the internet and can communicate with each other. Humans can for example send data to the network via smartphones or tablets and materials or goods can be equipped with beacons to send data about their location or condition. Other elements are, for example, IoT devices with an inherent intelligence to autonomously perform tasks of different complexity, such as handheld devices, cameras, detectors, or self-navigating vehicles.

Benefits of Logistics 4.0

The goals of Logistics 4.0 are inter-company optimization and automation of material flows and resource utilization in both inbound and outbound logistics. Companies that are building more digital capabilities in the context of logistics can create significant competitive advantages by reducing their costs and at the same time increasing customer satisfaction by improving service quality and minimizing delivery errors. Among other things, Logistics 4.0 creates value for companies in terms of:

Name	Description
Delivery reliability, quality, and flexibility	Delivery reliability is enabled through end-to-end tracking of items and assets, prediction of bottlenecks and delays and identification of risks. Higher quality of goods and services is achieved through condition monitoring of goods and monitoring of processes in real time. Flexibility can be increased based on capabilities to adapt to dynamic environments and suggest alternative routes or scenarios.
Increased transparency	The integration of entities and logistics processes along the entire supply chain creates comprehensive transparency and thus facilitates supply chain management and supports decision-making.
Automation of processes	Progressing digitalization and connection also facilitates partly or full automation. For example, processes or workflows can be supported or even fully automated by using robotic process automation (RPA), or cargo itself could become intelligent and organize its own transport autonomously.
Enhanced collaboration	The connection of entities in the supply chain enables a higher division of labor and efficient collaboration with partners, suppliers, and customers.
New services & business models	The extensive collection of data throughout the supply chain enables data-driven and platform-based business models with new types of revenue models and new ways of service provision to the customer, such as SaaS models (Software as a Service).

Table 1: Value of Logistics 4.0

Evolution from Logistics 1.0 to Logistics 4.0

Figure 1: Evolution of Logistics

Due to the lack of digital technologies, traditional logistics is less efficient, highly manual, and requires centralized and complex planning. Typical characteristics are paper-based documentation, manual input, and transfer of data between IT systems, scanning of documents and constantly making phone calls to update the latest cargo status. These characteristics illustrate the procedures of traditional logistics and reflect the current status quo of many companies.

The evolutionary stages from Logistics 1.0 to Logistics 4.0 over the course from the 19th to the 21st century can be described as follows:

Stage	Logistics 1.0: "Local logistics"	Logistics 2.0: "Region centric logistics"	Logistics 3.0: "Global logistics"	Logistics 4.0: "Interconnected global logistics"
Content	Mechanization of transport from animal force to the operation and utilization of railways and own vehicles.	Higher complexity for logistics due to a growing logistics sector and routes focusing on inter- and intra-regional clusters and large-scale utilization of equipment (e.g., trucks, ships, aircraft).	Strong involvement of 3rd party logistics service providers, as companies inevitably do not have a fleet available everywhere and in sufficient numbers. Transport remains an intermediate step in the client's business process.	Independent automated control of logistics across the entire business process of companies and collaboration between logistic enterprises - logistic customer service as a priority.

Table 2: Evolutionary stages of Logistics

3.3 Challenges and Opportunities of Logistics 4.0 for Hong Kong

Observed challenges in Logistics 4.0 for Hong Kong SMEs

During the visits of the selected pilot companies, various challenges in the general context of logistics and for the introduction of Logistics 4.0 were observed:

Independent introduction of Logistics 4.0

SMEs often do not have the skills themselves to implement Logistics 4.0, especially in logistics services providers. Manufacturing companies have to some extend already established teams who have built digital production applications and are now also working on logistics 4.0 applications. Most IT staff is focused on commercial IT systems like ERPs or very specific IT solutions to digitalize individual processes. In this context, operational and business model improvements are left behind. Here, more knowledge on IoT applications and a more process-oriented thinking need to be promoted.

Standardization of interfaces

Interfaces are not standardized. Every new vendor and value partner has to be integrated, which often requires considerable effort or may not be even possible due to technologic or organizational constraints. If time and costs do not bring sufficient savings, integration might not be worthy.

Utilization of classic and manual communication methods

Many customers are still used to make use of e-mail or even fax/telephone for communication. Companies see themselves confronted with the question why they should digitalize if their customers do not insist to do so or even lack the capabilities to work together through new digital means. However, a generation shift at customers can quickly turn this around from API integration being not desired to being absolutely mandatory for maintaining business relationships. Thus, it is recommendable for companies to act proactively and already encourage their customers to benefit from the utilization of digital solutions and digital integration today.

Missing proactive approach towards driving Logistics 4.0 implementation

Consumer-facing companies innovate faster and adapt to changing market demand more rapidly. Individualization and connection to platforms like Amazon, Taobao, T-Malls, JD.com drives internal digital capabilities. For many, this is a big challenge at the beginning, but once they have achieved it, it helps drive the overall digitization of the company. Observations in industry show that many companies stop at that point and digitalization is driven to exactly the point where it's needed to interoperate with platforms and rarely further. However, companies should take the opportunity to analyse what additional benefits could be achieved by improving their digital maturity and in which areas further action should be taken to, e.g., streamline operations, optimize processes, or develop data-driven business models for leverage competitive advantage.

Opportunities of Logistics 4.0 for companies in the GBA and ASEAN region

The opportunities of Logistics 4.0 for companies in the GBA and ASEAN region are divided into two groups and highlight below -

First, companies who do business in the GBA and ASEAN region to serve global customers with manufactured goods from the GBA or ASEAN region and then deliver to customers globally. Here, Logistics 4.0 can create business opportunities with regards to two main aspects:

1. With higher volatilities in supply chains and increasing compliance regulations imposed by governments worldwide, transparency and real-time tracking of shipments become clear Unique Selling Point (USP). Currently, many global customers (e.g., in Europe, the Americas, Middle East) make daily phone calls to ask suppliers about the exact position of their expected deliveries, e.g., whether it is on the ship, way, or how long it will still take. Providing this information in a digital form facilitates finding quicker and more adequate reactions. Thus, it saves costs for customers as the whole planning process from procurement over production to delivery can be adapted to the current situation.

2. In addition, the mentioned compliance requirements both in terms of CO_2 footprint and documentation of quality parameters can be significantly improved by automatic documentation and including features that allow a tracing of the full supply chain. For example, the capability to collect data on goods vibration to find the root cause for quality defects before the component is shipped to the customer to determine the exact position of shipments can lead to a competitive advantage and are already being demanded by customers around the world.

The development of these capabilities throughout companies in the supply chain is only progressing slowly. But eventually, every supply chain's tier will need to be able to handle this.

Secondly, for companies who are serving the GBA and ASEAN consumer markets, Logistics 4.0 can also create business opportunities with regards to two aspects:

1. Customers in these markets are already acquainted to very fast deliveries and tracking of deliveries through apps like Amazon, T-Malls, Taobao or others. To satisfy these requirements, companies anyway have to build the infrastructure to connect to these platforms and shouldn't stop once they reached that milestone. Instead, they should use the newly acquired knowledge and skills to optimize their own internal processes and further develop their business models to differentiate from competition, e.g., via customer segmentation into those who prefer more simple and cheaper services and those who are willing to pay more for higher value services based on the analysis of customer data.

Besides right pricing, flexibilization, speed and customization are the most important customer demands in this market. Companies should pursue business model innovation to offer matching goods and services that satisfy these demands. Here, logistics plays an integral role, as the more customization can be done in logistics, the more efficient the production can still be. Huge manufacturing organisations usually have complex defined processes for changes and bringing flexibility in any processes likes logistics has a long decision-making process due to the dependencies inside the organization. This is a key advantage of SMEs over big enterprises who can adapt faster.

4 Reader's Guide

In this document, a methodological approach towards Logistics 4.0 for the readers is introduced to understand the concept of Industry 4.0 and Logistics 4.0. This research highlights the challenges faced by the industries in Hong Kong and further explain the opportunities that are emerging. Various approaches such as surveys, assessments and market research have been followed to analyze the current conditions of the logistics services providers qualitatively and quantitatively based on which the key insights are derived.

The roadmap is specifically designed for logistics services providers companies to attain Logistics 4.0 maturity levels and it displays use cases that prove beneficial for improving the index score. Further the use cases are defined in detail to understand the exact application premise. The roadmaps are designed such that there are investment efforts in each dimension before moving to next level. It is therefore advised to approach the roadmap one level at a time. Further the use cases in the roadmap have been briefly defined.

Best practices of some of the world leading logistics companies provide knowledge of advances in the industry.

Finally, this document comes with a self-assessment tool to conduct a check-up at your company for measuring digital maturity index and plan investment for digitalization in suitable pilot projects.

5 Methodology

A. Assessment and Roadmapping Approach

HKPC and INC Invention Center conducted a total of 22 pilot assessments to gain a comprehensive overview about the status quo, existing challenges and next actions in the area of logistics in Hong Kong enterprises. To observe the maturity of Logistics 4.0 applications in logistics processes, interviews with the top management and relevant departments were conducted. For the visited departments and observed processes, multiple points from a portfolio of 150+ questions in 8 dimensions were considered and evaluated. The assessment structure and maturity level logic are based on the Logistics 4.0 Navigator developed by INC Invention Center, Fraunhofer IPT and HKPC as well as the Hong Kong Logistics 4.0 Maturity Model, which is derived from the Acatech Industrie 4.0 Maturity Index developed by German academic research organizations.

B. Logistics 4.0 Navigator

For a structured approach to the field of Logistics 4.0 and the conducted assessments, the Logistics 4.0 Navigator was developed. The navigator serves as a framework to depict the interaction of a unique business model (Uniqueness), technology-driven applications that implement the business model (Application) and the underlying technologies that enable these applications (Enablers).

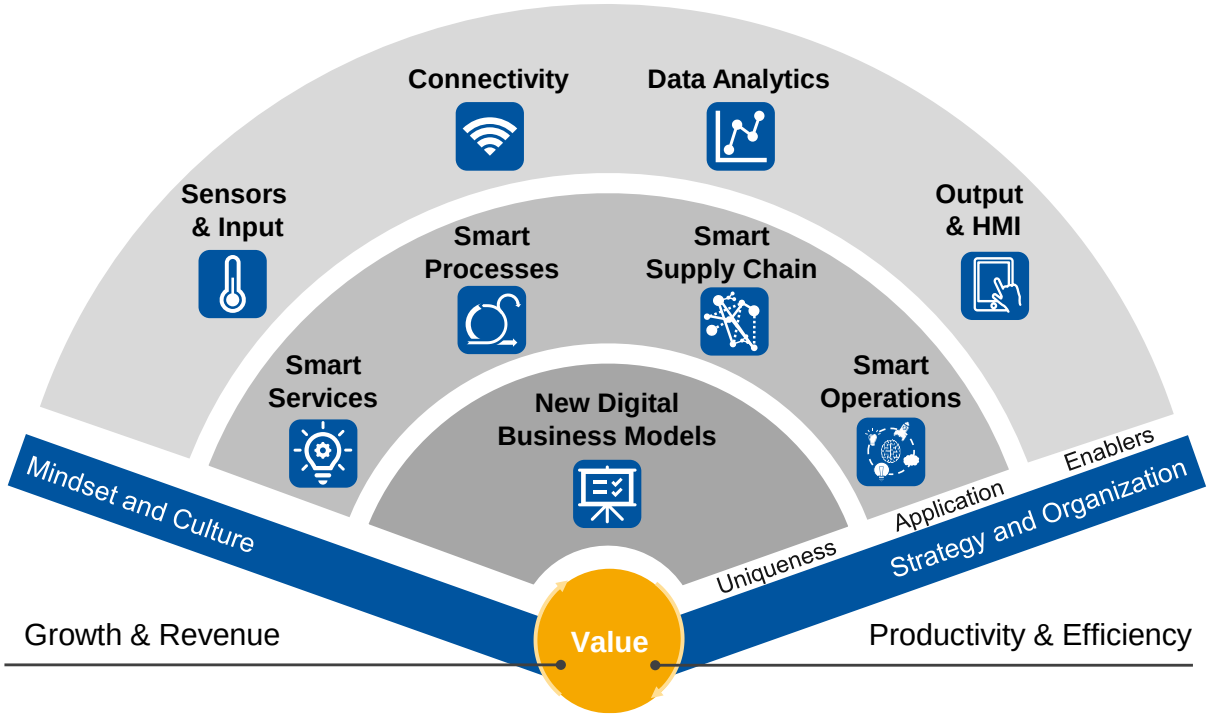


Figure 2: Logistics 4.0 Navigator

In the centre of the navigator stands value creation, as all activities of a company should be primarily aimed at creating value in some form. From the perspective of a company, value can be either generated in the form of growth and revenue or by reducing costs through enhanced productivity and

efficiency. For a successful business it is of utmost importance which value it creates for the customer. This value determines how successful a company will be in gaining and keeping satisfied customers and ultimately how successful a company will be in generating growth and revenue. To make enablers, applications and business models work together successfully with the ultimate target of value creation, a company needs a coherent "Strategy and Organization" as well as a supportive "Mindset and Culture". These aspects form the framework and internal environment for a prosperous business.

The fields of the Logistics 4.0 Navigator can be described as follows:

New Digital Business Models: The business model is the foundation of a company and determines whether it will be successful and grow. Industry 4.0 enables the creation of innovative digital business models that are based on data, developed, and improved with the help of data, and provided digitally to the customer.

Smart Services: The comprehensive collection of product and user data enables the offering of smart and value-added services according to the customers' needs and behaviour. In logistics, this can for example refer to monitoring of goods condition (e.g., temperature, force) and location or flexible routing and shipping according to the customers preferences.

Smart Processes: The integration of entities and goods along the full supply chain enables a seamless data exchange between systems, goods and involved stakeholders. In logistics, cloud-based IoT solutions and the continuous collection of goods-related data enable paperless logistics and efficient collaboration and processes.

Smart Supply Chain: Industry 4.0 technologies enable logistics systems to sense, process, self-learn, analyse, and make decisions to solve problems and execute processes. The smart supply chain is connected with smart production systems and other networks to gain a holistic overview over all logistics processes, detect potential bottlenecks and enable customer-centric logistics services.

Smart Operations: Connectivity and seamless data exchange also creates increased transparency inside companies. Internal departments and processes, such as warehousing and intra-logistics, can be managed and monitored better to provide reliable information, e.g., current stock levels or production delays quickly and as needed to internal and external stakeholders.

Sensors & Input: The application of sensors and acquisition of data from various IT systems enables the creation of a comprehensive digital picture of the real world. This creates transparency across logistics processes in the full supply chain and enables stakeholders to see what is happening. Sensors are becoming smaller, cheaper, and more versatile. They can measure more data in increasingly difficult to reach areas and interact with each other.

Connectivity: The connection of all elements in the value network through horizontal integration of the supply chain, vertical integration of enterprise systems, and the integration of the product life cycle from development to customer utilization are the backbone of Industry 4.0 and Logistics 4.0. Extensive networks can be established ad-hoc and automatic and allow access to data in the full supply chain.

Data Analytics: Capabilities to analyse data bring intelligence to the whole value chain and enable stakeholders to understand why something is happening, predict future events like supply bottlenecks and facilitate autonomous optimization like rerouting and replanning. Modern information and communication technology (ICT) supports the storage of data in the cloud and provides resources for high-speed computing as well as artificial intelligence (AI) applications.

Output & HMI: Besides machine-controlled processes, the provision of information to the user is a central topic in Logistics 4.0. Assistance systems like smartphones, tablets and other wearables facilitate the visualization of data for the user and provide user-specific and contextualized information. This can for example be used to inform transport operators about potential delays in the production of their customers or help a warehouse operator to quickly find and identify SKUs.

C. Hong Kong Logistics 4.0 Maturity Model

To better structure the transformation towards Logistics 4.0 in a stepwise approach, the Hong Kong Logistics 4.0 Maturity Model was developed and adapted to the situation and requirements of Hong Kong SMEs. The stages and logic behind the model are derived from the Acatech Industrie 4.0 Maturity Index developed by German academic research organizations.

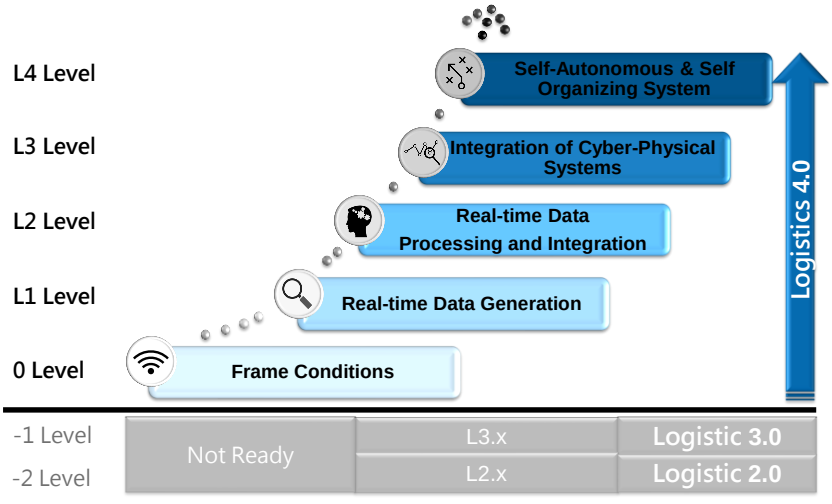


Figure 3:Maturity Levels

Every stage of the evolution towards Logistics 4.0 constitutes added value for companies and generates a competitive advantage. To ensure a sustainable development of capabilities, the transformation should be carried out successively and evenly across all departments and not in a quantum leap. In general, it should be noted that solutions up to level two are currently available, economically viable and thus suitable for industrial practice. Solutions from levels 3 and 4 are still partly under development and moreover dependent on high computing power, a high-performance IT

infrastructure and the availability and quality of big data from various sources and are therefore only suitable for application and economically viable for technologically advanced companies.

Logistics 2.0: Non-digital (Level -2)

Predominantly Logistics 2.0 process, i.e., labour intensive operations and manual information flow. Operations are highly manual and paper-based and proceed in an ad-hoc and chaotic rather than systematic manner:

- Chaotic operation (Low attention level on efficiency and effectiveness)
- Manual operation processes/works
- Mainly paper-based work
- No digitization (No information technology/system adopted)

Logistics 3.0: Systemization and Computerization (Level -1)

Predominantly Logistics 3.0 processes. Basic digitization and introduction of standalone IT systems for automation of single processes/tasks (e.g., e-mail & Fax) as well as basic systematization of processes:

- Operations not yet optimized (Low efficiency and effectiveness)
- Standalone automation processes/works in place
- Basic digitization in place for processes/works
- Low level of digitization (Limited/disconnected information technology/system adopted)

Logistics 4.0: Connectivity – Foundation Condition (Level 0)

Organizational and infrastructural enablers for the implementation of Logistics 4.0. Connection of internal IT systems without media breaks regarding the flow of information in the direction of the process:

- Logistics 4.0 awareness and culture built
- LEAN processes & reasonable networked automation
- IT-infrastructure and data security
- Data acquisition by sensor and IoT in real time for processes/works
- Standalone advanced digital tools adopted & mastered

Logistics 4.0: Visibility – "What is happening?" (Level L1)

Generation and availability of data and information of all activities in real time. Seamless information flow in all directions between internal and external information sources and IT systems, creating a "single source of truth" and transparency across all processes and activities:

- Vertical integration of advanced digital tools (e.g., DMS, SCM, PMS, WMS)
- Transport management, Fleet management, Track and Trace, APS, Route/Tour planning
- Well established "Single Source of Truth"
- Real time end-to-end operation status visualization
- Use of data for basic operation analysis (descriptive)

Logistics 4.0: Transparency – "Why does it happen?" (Level L2)

Development of knowledge and insights through the analysis and aggregation of all available information and data sources. Full aggregation of internal and external real-time data to identify cause-and-effect relationships between events and their root cause:

- Full digitalization & aggregation of real time data including EDI/APIs and IoT platform
- Collaboration within organization and agile management (e.g., planning/forecast ability & decision-making, improvement)
- Smart Data analytics and machine learning adopted & mastered

Logistics 4.0: Predictability – "What will happen?" (Level L3)

Predictive analytics and human-system / system-system collaboration for decentralized decision-making. Application of simulation models, which are built on the basis of real historical data and continuously improved, in order to predict the expected resulting scenarios for certain events or decisions:

- Decentralized decision-making
- HMI/MMI, Industrial apps
- Mobile assistance systems
- Close-loop process optimization over the whole logistics chain and predictive analytics

Logistics 4.0: Adaptability – "How can an autonomous reaction succeed?" (Level L4)

Self-optimizing processes and autonomous control of processes along the value chain. Addition of an automatic and autonomous evaluation function that can make a statement about which event or decision will lead to the best scenario to maximize the value for the company and for customers:

- Autonomous automation
- Self-learning, self-organizing and self-optimization

6 Key Insights for the Logistics Services Providers

A. Competitive markets drive the introduction of IT and tracking solutions

The introduction of new digital applications, IT systems and capabilities such as tracking & tracing is mostly driven by customer demand or competition. The COVID-19 pandemic has only accelerated the necessity to build digital capabilities as customers seek a higher comfort level in their purchases and providing transparency around the full spectrum of shipping and delivery parameters has become a crucial component for customer satisfaction and brand loyalty. A major pain point which was identified in the cross-industry survey is the inefficient communication and exchange between entities in the supply chain. However, a close integration of stakeholders in the supply chain is crucial for efficient collaboration and information exchange. For shippers, this issue could be tackled by creating a digital platform to increase transparency along the supply chain and reduce handling time and the latency of information flow.

*Increasing competition from digital platforms f*or logistics services is a major pain point for 33% of surveyed companies.

Furthermore, competitive environments increasingly pressurize companies to connect to digital platforms such as Taobao to offer products and services. Customers often prefer platforms as they have comprehensive service offerings, good customer experiences and open new choices to individualize services.

B. Digital integration of partners and customers, fleet management and tracking prevent late deliveries

Companies which do not experience external pressure from customers or competition to build new digital capabilities are often not actively or proactively pursuing the introduction of related IT systems or digital applications. However, observations during the company visits show that those companies which are more advanced in terms of IT systems and application of digital solutions, integration with partners and customers as well as the digital management of their transport fleet are better at avoiding human errors and late deliveries.

Observations from the assessments

Challenge: One visited company that provides logistics services for freight forwarding faced the challenge of very little direct integration with their partners for transportation services. As a result, most questions from customers had to be manually checked from various websites and through phone calls, which caused big efforts for the company.
Solution: A potential solution for this challenge would be a digital integration with partner transportation companies for direct access to tracking information through an API for standard formats without the need to manually log data in to a system or place phone calls. This would furthermore enable the company to extend the existing service offering and add premium value-added services to customers with specific needs.

C. Digital integration with customers and software-based planning prevents too low operating time of resource

Enhancing the digital integration with customers and the application of integrated planning software for, e.g., procurement, sales and distribution can prevent too low utilization of own transport fleet or pre-booked partners for logistics services as companies can anticipate the demand for certain routes and goods beforehand based on data and plan the distribution accordingly. However, many companies still perform manual planning on paper or supported by standard applications like Excel, which may lead to human errors and inefficiencies.

35% of surveyed companies stated, that they perform manual and paper-based planning, while 59% perform manual planning with software systems, especially in Excel files.

Only 14% of surveyed companies have capabilities to electronically update planning data in real-time, while 6% have capabilities to update at certain times.

Furthermore, the integration with customers and digital collection of customer data enables companies to better capture customer needs and buying behaviour, which in turn helps to anticipate demand and develop a better offer of additional services according to the market demand based on customer analytics.

63% of surveyed companies regard an improved recording of customer requirements as a driver for their digitalization agenda.

Performing demand forecasts based on the acquired customer data and feeding that into suitable integrated planning systems can be a major contributor to accurate planning of routes and utilization of the transport fleet and thus to optimize costs.

Observations from the assessments

Challenge: One visited company that provides printing products for the retail sector faced the challenge of irregular unexpected peaks in demand for retail label printing from customers. The company didn't have reliable forecasting capabilities and had to respond quickly, which caused high effort and often resulted in bottlenecks and longer handling times.

Solution: A potential solution for this challenge would be a direct integration with customers, collection of customer data and the setup of efficient information channels for direct interaction with customers to receive requests of as quickly as possible to enhance planning and forecasting capabilities and schedule production accordingly.

D. The introduction of fleet management is driven by planning and regulatory needs

Capabilities to track and trace the location and utilization of the transport fleet are mainly built due to direct customer requirements or regulatory needs. However, observations in practice show that there is quite some resistance against such applications, as stakeholders often don't see the direct value of it and feel like these monitoring capabilities are used to put more pressure on them for a higher performance.

25% of surveyed companies perform no tracking of vehicles, while 19% do it manually via phone calls and another 35% support this process with software. Only 15% get electronic updates on the location of vehicles at certain times.

However, the introduction of fleet management, e.g., via a transport management system (TMS) offers various benefits such as gaining transparency about the current status of the transport fleet and planning, executing and optimizing the shipment of goods in one integrated software solution.

E. Close interaction with partners and end-to-end tracking of processes help to create transparency and optimize resource utilization

For companies, especially global players of bigger size, it is beneficial to enable end-to-end process tracking. This can be performed not only throughout internal processes but also throughout vendors, transport providers and solution providers. Thus, close digital interactions with partners, customers, suppliers, and solution providers can help in order to increase transparency in the full value chain and optimize resource utilization.

33% of surveyed companies stated that one of their major pain points in logistics processes is a lack of transparency.

A lack of transparency in logistics processes often arises from media breaks within the company or between different entities using standalone IT systems of paper-based processes.

Observations from the assessments

Challenge: A visited company that provides supply chain solutions and services faced the challenge of lacking transparency in own operations, especially in the warehouse, due to missing integration. The daily tasks of warehouse staff were highly manual, without the support of digital tools. Everything is paper-based, manual calculations as well as manual handling and locating of goods are necessary. Furthermore, the actual physical stock levels are not digitally integrated into the WMS, i.e., inventory is done manually, documented on paper and then fed back manually into the WMS, which lead to discrepancies between actual physical inventory levels and WMS data.

Solution: A potential solution to that problem is to implement a barcode system and deploy IoT devices such as handheld scanners that are integrated into the WMS for operations like receiving, replenishment, order picking and inventory to reduce manual documentation effort and prevent human errors. Furthermore, the application of IoT devices facilitates digital process tracking to monitor operational KPI and find levers for optimization based on, e.g., lean principles.

33% of surveyed companies track processes manually and paper-based, while 49% track processes manually with software support. Less than 5% are able to digitally monitor processes and electronically update data either in real-time or periodically.

With regards to internal processes, the implementation of sufficient IT systems to support and accelerate operations (e.g., planning processes or warehouse management) can lead to more transparency, offer saving potentials and make paper-based documentation obsolete. Digital tracking of processes facilitates performance monitoring for defined business KPIs and the identification of bottlenecks and inefficiencies. In this context, companies can implement digital lean, which aims at continuous improvement of processes based on the continuous collection and analysis of data according to lean principles.

68% of surveyed companies stated that they see process acceleration as one of the major drivers for digitalization.

F. Digital integration with customers, scheduling & goods tracking tools reduce handling time

The digital integration with customers as well as the application of digital scheduling and tracking systems can help to reduce handling time as it enables companies to anticipate when an action is needed and at the same time ensure that the relevant resources, e.g., workers or transport devices are available and scheduled.

29% of surveyed companies suffer from high handling time in logistics processes.

The tracking of goods enables a more accurate prioritization and scheduling of activities to reduce handling time and allocate resources efficiently. Furthermore, companies can provide customers with information on goods location, e.g., via individual access on online platforms or automatic e-mails and thus tap new revenue streams through value-added services. However, many still lack sufficient tracking capabilities and perform the process manually.

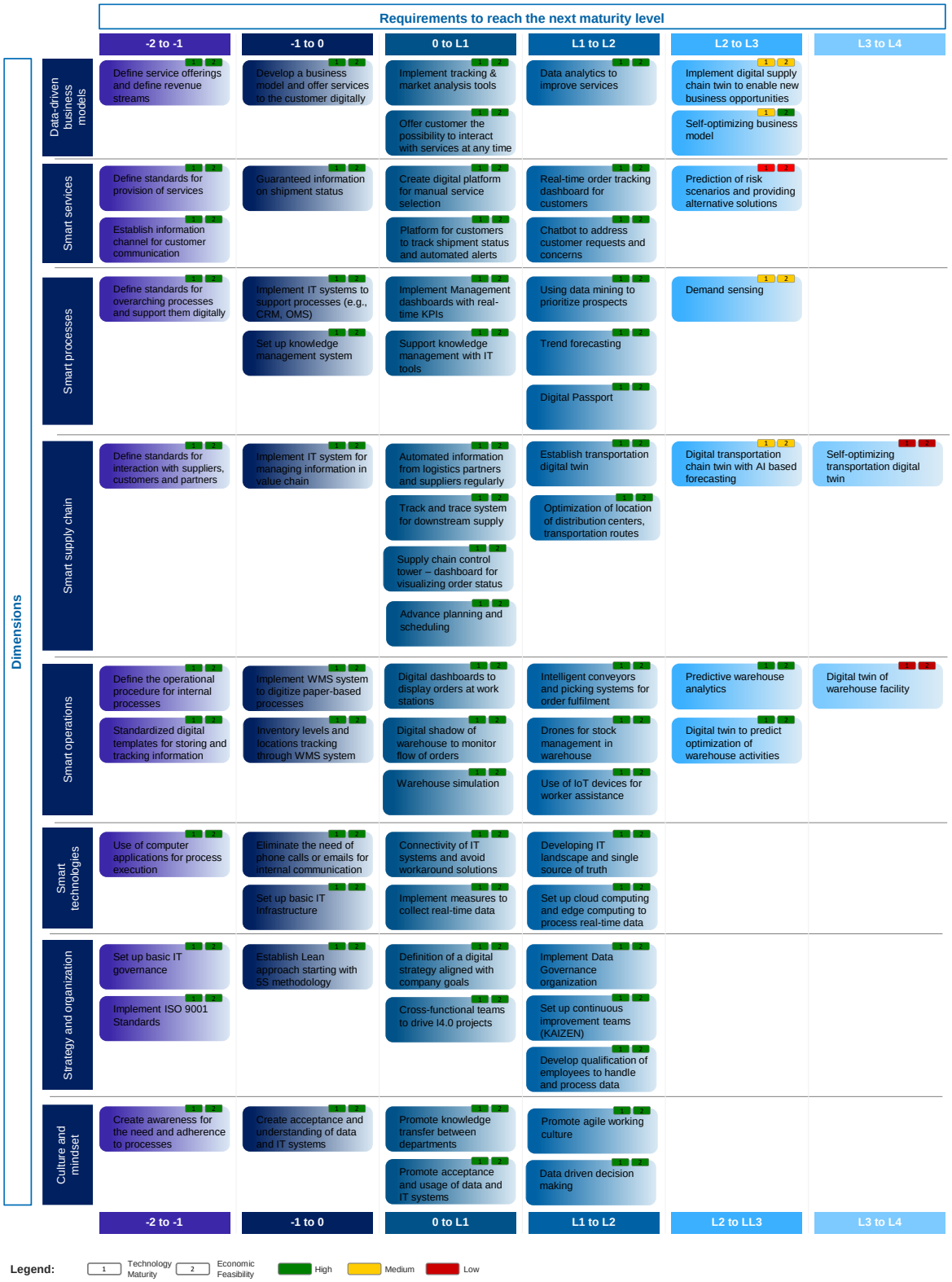
51% of companies manually track goods with software, i.e., the location of goods is communicated via e-mail or phone and manually inserted in an IT system. 29% of the surveyed companies perform this process via paper-based system. Only 10% receive automatic updates on goods location at certain times and 8% have real-time access to goods location.

G. Regulatory constraints drive introduction of digital solutions in scheduling +resource tracking

Regulatory requirements are among the major drivers for introducing digital solutions for scheduling and resource tracking. Besides regulatory constraints, customer requirements are important drivers for the implementation of relating systems. Observations in industry show that as soon as soon as companies implement these systems, they can improve their operations significantly. Consequently, it is recommendable to proactively analyse the potentials of digital solutions for operations before external factors force the implementation.

7 Roadmap for the Logistics Services Providers

Roadmap including use cases for step-by-step transformation towards Logistics 4.0



8 Logistics 4.0 Use Cases and Applications

Further detailing the benefits of each pilot project in the roadmap and describing the specific use case or application.

Level -2 to -1: The first step is the transformation from no digitization, highly manual and paper-based (rather ad-hoc and chaotic than systematic) operations into predominantly logistics 3.0 processes.

-2 to -1	**Define service offerings and define revenue streams** 1 2
Data-driven business model	Define the services and products that can be offered to the customers and define how revenue is generated from the core business activities. Define the deliverable value, develop a general pricing strategy and scope of the service. This is a crucial step to prepare future business strategies and find new revenue streams.
-2 to -1	**Define standards for provision of services** 1 2
Smart services	Define how to provide the customer with the promised value through services. Describe the possible shipment methods for different types of products to determine how they can be delivered to the customer. Having a clear outline will drive customer satisfaction.
-2 to -1	**Establish an information channel for customer communication** 1 2
Smart services	Develop standard communication emails or fax to provide the direct customers with information on the status of the shipment, expected delivery date and other significant details on their order. Define an internal code of conduct for communicating with the customers.
-2 to -1	**Define standards for overarching processes & digital support** 1 2
Smart processes	Standardise the functions of the business departments like human resource management, sales, marketing, finance, and accounting, for coordinating with the operational departments (e.g., define standard recruiting and onboarding process) and create digital standard templates to support their activities (e.g., excel template for RFQs).
-2 to -1	**Define standards for interaction with suppliers, customers & partners** 1 2
Smart supply chain	Develop supply chain interaction by ensuring access to information in a standardised format for customers and suppliers and coupling organisational processes with partners in the supply chain (e.g., standards to book shipment, a standard process for selection of transportation partners).
-2 to -1	**Define the operational procedure for internal processes** 1 2
Smart operations	Clearly define the operational procedure for internal logistics processes from receipt to dispatch. Streamline the operations by defining the standard flow of product through the warehouse (e.g., define process flow diagrams in Excel). Document the steps of the tasks and the sequence in which they should be performed and the responsible employee who should do it. This raises a sense of responsibility amongst the workforce.

-2 to -1	**Standardised digital templates for storing and tracking information**	1 2
Smart operations	Definition of standardised digital templates for storing and tracking information (e.g., standard Excel templates for managing inventory levels at all distribution centres, recording inbound and outbound entries).	
-2 to -1	**Implement computer applications and digital interfaces for process execution**	1 2
Smart technologies	Start the use of digital technologies by using computer applications to execute all departmental functions and systematically record data (e.g., filling handwritten forms substituted by digital forms). Conduct cross-department information transfer via e-mails. This increases the efficiency of the processes by reducing time required for documentation of the communication (e.g., taking notes during a phone call instead of an email) and being limited by the physical characteristics of information storage.	
-2 to -1	**Set up basic IT governance**	1 2
Strategy & organisation	Enable effective and efficient use of IT in the organisation by setting up a basic IT governance system. Define Information Technology goals and align the organisations' business goals to support computerisation. By following a formal framework, organisations can produce measurable results by taking stakeholders' interests into account.	
-2 to -1	**Define a vision and goals**	1 2
Strategy & organisation	Define a vision for how digital applications can improve service, cost, agility, and inventory levels while consistently implementing process and organisational changes that use these technologies to drive operational excellence.	
-2 to -1	**Implement ISO 9001 Standards**	1 2
Strategy & organisation	The process approach promoted by ISO 9001 systematically identifies processes that are part of a quality system and identifies the interactions between them and may be applied on all processes. This concept follows the Plan, Do, Check, Act cycle for implementing change which, when followed and repeated, would lead to repeated improvements in the process it was applied to.	
-2 to -1	**Create awareness for the need and adherence to processes**	1 2
Culture & mindset	The corporate culture, as a totality of action patterns as well as convictions that are accepted as binding in a company, represents the basis for the way of cooperation. In order to gain commitment, it is therefore important to create awareness of the necessity of the processes and trust in them.	
-2 to -1	**Establish process guides and guidelines**	1 2
Culture & mindset	Consistent implementation of the guiding principles leads to improved efficiency in the processes. A process map as a guideline, for example, can help to track and further refine the processes and can be used as a reference and guidance for new employees.	

Level -1 to 0: Basic digitization and introduction of standalone IT systems for automation of single processes or tasks are implemented as well as basic systemization of processes are done. The next

stage with connections to internal IT systems without media breaks can be achieved by introducing the following steps.

-1 to 0	**Develop a business model and offer services to the customer digitally**	1 2
Data-driven business model	Develop a business model by identifying the key customers and establish a strong value proposition through products and services. Customers should be able to access the offerings through digital platforms (e.g., the company website).	
-1 to 0	**Guaranteed information on shipment status**	1 2
Smart services	Customer service representatives must have access to the information on the status of the customer order to provide guaranteed information regarding the status of the shipment and can provide exact dates on when the customer can expect the shipment to arrive. Regular information sent through emails , SMS, direct messages to the customer to provide order related information improve customer relations.	
-1 to 0	**Implement IT systems to support processes (e.g., CRM, OMS)**	1 2
Smart processes	For the execution of defined tasks, implement the required IT systems (e.g., Customer relationship management solution, Order management system) by considering the functional requirements. Along with cost, it is also important to take into account the factors like scalability, usability, integration with other systems.	
-1 to 0	**Set up knowledge management system**	1 2
Smart processes	A knowledge management tool helps in organising information and documentation that can be accessed by everyone in the organisation. Implement an organisation wide IT system to store process know how and create a knowledge base to improve understanding and promote collaboration between the departments.	
-1 to 0	**Implement IT system for managing information in value chain**	1 2
Smart supply chain	Engage with the stakeholders in the value chain through digital interfaces by implementing IT systems. Evaluate and manage supply chain partners by implementing a supplier relationship management tool to improve operational efficiency. Implement a TMS system to plan and execute the transportation process and store related documents.	
-1 to 0	**Implement WMS system to digitize paper-based processes**	1 2
Smart operations	Warehouse management system provides visibility in handling warehousing functions. Implement a WMS system to track goods and material movement through the warehouse, track inventory levels, and manage order fulfilment process.	

-1 to 0	**Inventory levels and locations tracking through WMS system**	1 2

Smart operations	Tracking SKUs in possession and their storage locations to create visibility on the inventory by using a barcode system for identification of the material in the warehouses and distribution centres.
-1 to 0	**Eliminate the need of phone calls or emails for internal communication** 1 2
Smart technologies	By providing access to the right IT systems for obtaining necessary information, internal communication via emails and phone calls can be eliminated. Latency for gaining critical information will be reduced, thus productivity will be improved.
-1 to 0	**Set up basic IT Infrastructure** 1 2
Smart technologies	For the introduction of digital technologies and IT systems, an IT infrastructure must be developed to operate and manage the physical and network components of an enterprise IT landscape.
-1 to 0	**Establish Lean approach starting with 5S methodology** 1 2
Strategy & organisation	Follow lean methodology approach for optimisation of available resources in the organisation to create value for the customer. Create sustainable processes starting with 5S to eliminate waste and standardise working habits. Map value stream to recognise the wastes and implement Kanban pull principle to increase throughput.
-1 to 0	**Create acceptance and understanding of data and IT systems** 1 2
Culture & mindset	Create awareness of the importance of usage of IT systems and data for better acceptance of these tools.

Level 0 to L1: The next level to be reached offers a seamless, real-time information flow in all directions between internal and external information sources and IT systems. Creating a "single source of truth" and more transparency across all processes and activities is one of the main tasks in this level.

0 to L1	**Implement tracking and market analysis tools**	1 2
Data-driven business model	Implement tracking and market analysis tools to analyse the performance of business model. These tools allow more efficient adjustment at a later stage.	
0 to L1	**Offer customers the possibility to interact with services at any time**	1 2
Data-driven business model	Customers can access the services online and interact digitally to request customisation of transportation methods and related prices. Make services available digitally to enrich the customer experience.	
0 to L1	**Create a digital interface for manual service selection**	1 2
Smart services	Create a digital interface for customers (e.g., online platform with login) for permanent access to product- and order-related information (e.g., status, expected arrival) and manually select additional services.	
0 to L1	**Platform for customers to track shipment status and automated alerts**	1 2
Smart services	Customers can track their shipment via an online platform and get automated notifications (e.g., by e-mail, in the event of delivery delays, etc.).	
0 to L1	**Implement management dashboards with real-time KPIs**	1 2
Smart processes	To visualise relevant processes with real-time KPIs, management dashboard should be implemented. This allows to keep an overview and have the KPIs relevant for decision-making sorted at a glance.	
0 to L1	**Support knowledge management with IT tools**	1 2
Smart processes	Formalise knowledge management (e.g., action sheets for improvement actions, learnings from specific situations) in a process and support this with simple IT tools (e.g., WIKI, SharePoint).	

0 to L1	**Automated information from logistics partners & suppliers regularly**	1 2
Smart supply chain	Automatic provision of information from the transport or logistics partners for making decisions regarding transport scheduling.	

0 to L1	**Track and trace system for downstream supply**	1 2
Smart supply chain	Implement track and trace capabilities to visualise the status of shipment orders to get real-time intelligence and drive strategic operational decisions. Therefore, the application of IoT devices is helpful and should be implemented, such as a scanner & barcode system.	

0 to L1	**Supply chain control tower – dashboard for visualising order status**	1 2
Smart supply chain	Track loads across roads, rails and oceans and receive accurate information about shipment arrival times. Visualise key performance metrics and get an overview of carriers.	

0 to L1	**Advance planning and scheduling**	1 2
Smart supply chain	Coordinate distribution activities by implementing APS to consolidate shipments, sequencing pickup and delivery locations, maximise fleet utilisation, and minimise transportation costs.	

0 to L1	**Digital dashboards to display orders at workstations**	1 2
Smart operations	Implement digital dashboards at workstations to display the current orders and display operational KPIs. Dashboards provide visual information to the employees on the overall performance.	

0 to L1	**Digital shadow of warehouse to monitor flow of orders**	1 2
Smart operations	Digital shadow of a warehouse captures the data of the physical warehouse to gain more visibility in the process. All warehouse activities are collected and stored in a digital format which can be used to visualize and monitor the flow of materials in an order.	

0 to L1	**Warehouse simulation**	1 2
Smart operations	Use of a computer model to simulate warehouse and its functionalities to experiment with layout planning in a virtual setting, reducing the time and costs involved with physical testing.	

0 to L1	**Connectivity of IT systems and avoid workaround solutions**	1 2
Smart technologies	Implement interfaces between IT systems and applications to support information sharing and transfer to reduce non-value adding activities and free employees from laborious task of entering data from one system to another while disabling workarounds.	
0 to L1	**Implement measures to collect real-time data**	1 2
Smart technologies	Sensors increase the level of automated collection of data. Thus, the processing and enhanced visibility across the supply chain helps companies to reduce operating costs and improve asset efficiency. Inventory monitoring can become more automated with the assistance of a sensor infrastructure, thus helping to improve the productivity.	
0 to L1	**Definition of a digital strategy aligned with company goals**	1 2
Strategy & organisation	Defining a strategy is an essential part of the transformation process to ensure that technology is deployed in a way that supports business goals and can be divided into digital objectives.	
0 to L1	**Cross-functional teams to drive L4.0 projects**	1 2
Strategy & organisation	Interdisciplinary teams (technical teams from different domains and backgrounds) should be established to implement and steer Industry 4.0 projects e.g., for the implementation of IoT applications.	
0 to L1	**Promote knowledge transfer between departments**	1 2
Culture & mindset	Knowledge transfer is a method of sharing information, abilities, and ideas across different areas in a business. Knowledge transfer systems aid in structuring and organising the knowledge which in turn ensures that everyone in the company has the information they need.	
0 to L1	**Promote acceptance and usage of data and IT systems**	1 2
Culture & mindset	It is fundamental for employees inside of a company to accept the newly introduced systems and new tasks coming with a transformation. To successfully do this, the value of every change and adjustment has to be communicated clearly and be understood by the affected employees. This can be done through trainings, courses, promoting good examples though intranet pages towards other employees etc.	

Level L1 to L2: With the transformation from level L1 to L2 the goal is to achieve a full aggregation of internal and external real-time data to identify cause-and-effect relationships between events and their root cause.

L1 to L2	**Data analytics to improve services**	1 2
Data-driven business model	Using data analytics and transforming the business models in parallel will create new opportunities for revenue streams, customers, products and services.	
L1 to L2	**Real-time order tracking dashboard for customers**	1 2
Smart services	Allowing users to track freight shipments to create shipment visibility in real-time. An online platform provides live tracking of ongoing transportation operations and notifications for shipment delays with updated ETA which improves customer satisfaction in a cost-effective way.	
L1 to L2	**Chatbot to address customer requests and concerns**	1 2
Smart services	When a customer faces an issue or wants adjustments done with an ordered product, a virtual assistant acts like a human agent and helps the customer by answering to their concerns, questions and provides relevant information on the product and/ or service. The chatbot is also able to give recommendations and solutions to the customer of what to do next and how to solve his/ her issue. The data of the chatbot can be used to understand trends and drive root cause analysis.	
L1 to L2	**Using data mining to prioritize prospects**	1 2
Smart processes	Create better sales and marketing strategies for prioritising customer groups by using data mining techniques. Gain useful information from raw data to understand customer needs.	
L1 to L2	**Trend forecasting**	1 2
Smart processes	By analysing millions of real-time online consumer conversations, trend forecasting evaluates, ranks and predicts every trend category by its future growth potential to determine which trends will matter most.	
L1 to L2	**Digital Passport**	1 2
Smart processes	A blockchain-based solution that helps in determining and proving provenance of a product between supply chain nodes. Increase in the quality and safety of products when being transported. Unique digital ID for a paperless audit trail that can be used for automated milestone payment using smart contracts.	

L1 to L2	**Establish transportation digital twin**	1 2
Smart supply chain	Create a virtual twin of the physical transportation network to visualize, monitor and analyse the movements of transport vehicles in real-time. Better decision making based on real-time data enables optimisation.	

L1 to L2	**Optimization of location of distribution centers, transportation routes**	1 2
Smart supply chain	To reduce transportation costs and times, strategic planning and optimization of warehouse location and transportation routes requires to consider various factors which can be optimized using analytics.	

L1 to L2	**Intelligent conveyors and picking systems for order fulfilment**	1 2
Smart operations	Use of omni-directional conveyor belt with decentralized intelligence to enable individual package routing as well as sorting and grouping tasks. Module-based conveyor systems enable flexibility through variable flow directions, intuitive plug-and-play installation, and scalability through a decentralized approach. Using image recognition-based system combines hardware and software to automatically pick and place each item onto the right place zone/conveyor.	

L1 to L2	**Drones for stock management in warehouse**	1 2
Smart operations	Simplifying the warehouse inventory tracking by using an autonomous drone for inventory audit, item search, stock taking. Also, useful to efficiently identify and analyse packages and possible damages.	

L1 to L2	**Use of IoT devices for worker assistance**	1 2
Smart operations	Use of mobile devices, wearables, AR to provide expert support and work instructions and ensure correct handling of material and accomplish tasks with higher productivity.	

L1 to L2	**Developing IT landscape and single source of truth**	1 2
Smart technologies	Integrate domain-specific application software to establish a single source of truth architecture. Remove any system discontinuities by aggregating data from multiple systems in a single location to ensure that up-to-date and correct data is available at any point in time.	

L1 to L2	**Set up Cloud and edge computing to process real-time data**	1 2
Smart technologies	Cloud or edge computing solutions add data processing capability to the automation environment. Data can thus be collected locally on the shop floor, be processed without long transmission paths to the cloud or edge computing location which then processes the data. This offers a device-, platform- and location-independent processing of data.	
L1 to L2	**Implement data governance organisation**	1 2
Strategy & organisation	Data governance refers to the organisational policies and procedures that govern data management. Data governance guarantees that data is safe and secure. It also ensures that the data provided is protected, reliable, documented and controlled. Evaluated data governance is also a practice that needs to be cultivated and kept alive and vital. It is about having a common and shared understanding of it, and efficiently and effectively managing it in order to optimise business value.	
L1 to L2	**Set up continuous improvement teams (KAIZEN)**	1 2
Strategy & organisation	The continuous improvement team is actively engaged in defining and implementing projects while managing the overall process. They are immersed in every aspect of the process and may be an active leader or participant in a project.	
L1 to L2	**Develop qualification of employees to handle and process data**	1 2
Strategy & organisation	During the maturity change process, various job positions will disappear, change and new ones will be created. Train existing employees to use their knowledge of the current processes to perform value adding activities. In the last two levels, however, there will be a need for educated and skilled workers in the field of computing, self-learning algorithms and data analysis.	
L1 to L2	**Promote agile working culture**	1 2
Culture & mindset	An important part of an agile work culture is increasing flexibility in many forms. It is an effective way of working in a project that promotes collaboration on all levels with a common goal. Culturally and mentally, employees have to be flexible to think about out-of-the-box solutions, adapt to changing needs, dive into new topics and cooperate with employees outside of their normal department, leaving their comfort zone.	
L1 to L2	**Data-driven decision making**	1 2
Culture & mindset	The aim is to build a culture that encourages all employees of the company to collaborate to keep data at the centre of decision-making, from the data owner to the data scientist, to the business analyst, and finally to every employee who uses data in their department. Data-driven cultures are enabled by access to data, management of data quality, methodological knowledge for analysing data, and technologies that enable them to be prepared and analysed.	

Level L2 to L3: The transformation to level L3 needs predictive analytics and human-system and system-system collaboration for decentralised decision-making.

L2 to L3	**Implement digital supply chain twin to enable new business opportunities**	1 2
Data-driven business model	Implementation of digital supply chain twin for 3PL and 4PL partners to work closely with manufacturing industries and manage their logistics operations based on the manufacturer's delivery plan.	
L2 to L3	**Self-optimizing business model**	1 2
Data-driven business model	New Services and business models are developed or adjusted by the system using data from market analysis and historical data in collaboration with customers. Possible options are presented and can be selected by management.	
L2 to L3	**Prediction of risk scenarios and providing alternative solutions**	1 2
Smart services	Identification, assessment and management of risks in transportation taking into account internal and external data like economic and political events. This helps to proactively identify, analyse and mitigate all types of risks. It provides the opportunity to turn risk into competitive advantage, for example, by offering revenue maximizing alternatives through the system.	
L2 to L3	**Demand sensing**	1 2
Smart processes	Support transportation planning by using demand sensing that uses AI methods with real-time information to create accurate forecast of demand based on real events.	
L2 to L3	**Digital transportation twin with AI based forecasting**	1 2
Smart supply chain	Digital twin of entire logistics network, including the assets, to capture dynamic data with modern GIS systems such as information on traffic densities, weather conditions, congestions and delays at ports, airports and borders can help in forecasting the future conditions and optimize conventional logistics networks.	
L2 to L3	**Predictive warehouse analytics**	1 2
Smart operations	Achieve shorter cycle times, lower inventories, lower costs and better customer service by implementing analytics that predict the likelihood of upcoming future events that may disrupt the normal process based on large sets of historical data. This provides the flexibility to react and make changes to the current operational conditions that lead to order fulfilment.	
L2 to L3	**Digital twin to predict optimisation of warehouse activities**	1 2
Smart operations	Accurately recreate warehouse systems and operations digitally by implementing enabling technology to integrate physical assets and collect real-time data that represents real world behaviour. Manage and improve processes and develop optimization scenarios for fast rotation of SKUs to improve global operational performance.	

Level L3 to L4: To achieve level L4 an automatic and autonomous evaluation function has to be added that can predict and evaluate which event or decision will lead to the best scenario as well make intelligent decisions to maximize the value for the company and its customers.

L3 to L4	**Self-optimising transportation digital twin**	1 2
Smart supply chain	Create a full-fledged, digital representation of the entire transportation network including all its current and potential entities. This enables the digital twin to continuously optimize all logistics processes based on a continuously expanding source of information from easily available public information, partner-related integrated data as well as indirectly correlated influencing factors. Throughout a system like this, the predictive models are continuously adjusted with new and self-enhancing algorithms to create sophisticated future scenarios based on potential disruptions or predicable changes in the supply chain. This will enable the use case to show alternative suppliers enhanced with all decision relevant parameters. Further delegate automated actions and intelligent decision making to IT systems in shortest possible time.	
L3 to L4	**Digital twin of warehouse facility**	1 2
Smart operations	Fully automated and connected warehouse facilities that can adapt to peak demand periods and respond to customer demands through continuous optimization. Improve process performance through decisions made by intelligent systems based on real-time operational data. Use of machine learning algorithms to choose best scenario to meet unexpected fluctuations.	

9 Self-Assessment Manual

A self-assessment tool was developed together with the cross-industry roadmaps. The tool helps companies to independently assess their own Logistics 4.0 maturity level. For this purpose, a collection of questions in various dimensions is provided, which are derived from the Logistics 4.0 Navigator. After answering all the questions, companies receive an individual assessment score. This score can be used to quantitatively depict the status quo of developments with regard to Logistics 4.0 and enables the company to position itself in the cross-industry roadmap. This enables the selection of suitable use cases and actions from the roadmap in the next step for a stepwise transformation to Logistics 4.0.

A. Dimensions of the self-assessment

Data-driven Business Models - Innovative business models that involve data are developed, and improved with the help of data, and presented digitally to the customer.

Smart Services & Processes - Commercial functions, digital and value-added services offered to customers and processes in the company without a physical counterpart (e.g., finance, HR).

Smart Supply Chain & Operations - Operational functions, their interactions, and exchange between entities in the entire supply chain and processes in the company with physical counterpart (e.g., warehousing, intra-logistics).

Information Technology (Networks & Data) - Enabling technologies and IT infrastructure for data transmission and analysis as well as available IT systems.

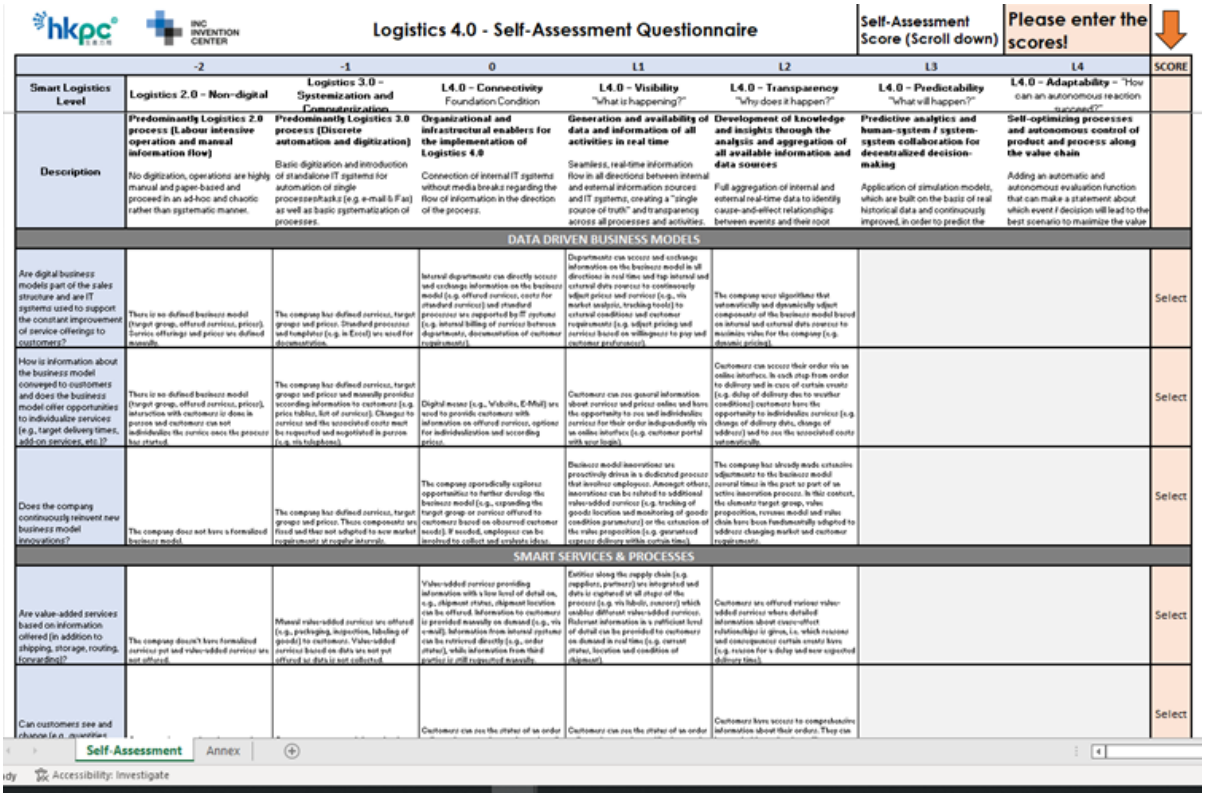
IoT (Sensors & Output) - Enabling IoT technologies for data generation about goods and assets in the supply chain.

Strategy & Organization - Defining a strategy for implementing Logistics 4.0 and creating conducive organizational structures.

Culture & Mindset - Culture and willingness in the company for collaboration among employees, the handling of data and utilization of digital tools to support decisions and execute processes.

B. Application of the Self-Assessment Tool

To use the self-assessment tool, users must answer questions 1-20. To do this, the answer that applies to the company must be chosen in the columns and the corresponding score must be selected in the orange field in column J (see picture).



Logistics 4.0 - Self-Assessment Questionnaire

Self-Assessment Score (Scroll down) | Please enter the scores!

	-2	-1	0	L1	L2	L3	L4	SCORE
Smart Logistics Level	Logistics 2.0 – Non-digital	Logistics 3.0 – Systemization and Computerization	L4.0 – Connectivity Foundation Condition	L4.0 – Visibility "What is happening?"	L4.0 – Transparency "Why does it happen?"	L4.0 – Predictability "What will happen?"	L4.0 – Adaptability – "How can an autonomous reaction succeed?"	
Description	**Predominantly Logistics 2.0 process (Labour intensive operation and manual information flow)** No digitization, operations are highly manual and paper-based and proceed in an ad-hoc and chaotic rather than systematic manner.	**Predominantly Logistics 3.0 process (Discrete automation and digitization)** Basic digitization and introduction of standalone IT systems for automation of single processes/tasks (e.g. e-mail & Fax) as well as basic systematization of processes.	**Organizational and infrastructural enablers for the implementation of Logistics 4.0** Connection of internal IT systems without media breaks regarding the flow of information in the direction of the process.	**Generation and availability of data and information of all activities in real time** Seamless, real-time information flow in all directions between internal and external information sources and IT systems, creating a "single source of truth" and transparency across all processes and activities.	**Development of knowledge and insights through the analysis and aggregation of all available information and data sources** Full aggregation of internal and external real-time data to identify cause-and-effect relationships between events and their root	**Predictive analytics and human-system / system-system collaboration for decentralized decision-making** Application of simulation models, which are built on the basis of real historical data and continuously improved, in order to predict the	**Self-optimizing processes and autonomous control of product and process along the value chain** Adding an automatic and autonomous evaluation function that can make a statement about which event / decision will lead to the best scenario to maximize the value	
DATA DRIVEN BUSINESS MODELS								
Are digital business models part of the sales structure and are IT systems used to support the constant improvement of service offerings to customers?	There is no defined business model (target group, offered services, prices). Service offerings and prices are defined manually.	The company has defined services, target groups and prices. Standard processes and templates (e.g. in Excel) are used for documentation.	Internal departments can directly access and exchange information on the business model (e.g. offered services, costs for standard services) and standard processes are supported by IT systems (e.g. internal billing of services between departments, documentation of customer requirements).	Departments can access and exchange information on the business model in all directions in real time and tap internal and external data sources to continuously adjust prices and services (e.g., via market analysis, tracking tools) to external conditions and customer requirements (e.g. adjust pricing and services based on willingness to pay and customer preferences).	The company uses algorithms that automatically and dynamically adjust components of the business model based on internal and external data sources to maximize value for the company (e.g. dynamic pricing).			Select
How is information about the business model conveyed to customers and does the business model offer opportunities to individualize services (e.g., target delivery times, add-on services, etc.)?	There is no defined business model (target group, offered services, prices), interaction with customers is done in person and customers can not individualize the service once the process has started.	The company has defined services, target groups and prices and manually provides according information to customers (e.g. price tables, list of services). Changes to services and the associated costs must be requested and negotiated in person (e.g. via telephone).	Digital means (e.g., Website, E-Mail) are used to provide customers with information on offered services, options for individualization and according prices.	Customers can access general information about services and prices online and have the opportunity to use said individualize services for their order independently via an online interface (e.g. customer portal with user login).	Customers can access their order via an online interface. In each step from order to delivery and in case of certain events (e.g. delay of delivery due to weather conditions) customers have the opportunity to individualize services (e.g. change of delivery date, change of address) and to see the associated costs automatically.			Select
Does the company continuously reinvent new business model innovations?	The company does not have a formalized business model.	The company has defined services, target groups and prices. These components are fixed and their not adapted to new market requirements at regular intervals.	The company sporadically explores opportunities to further develop the business model (e.g., expanding the target group or services offered to customers based on observed customer needs). If needed, employees can be involved to collect and evaluate ideas.	Business model innovations are proactively driven in a dedicated process that involves employees. Amongst others, innovations can be related to additional value-added services (e.g. tracking of goods location and monitoring of goods condition parameters) or the extension of the value proposition (e.g. guaranteed express delivery within certain time).	The company has already made extensive adjustments to the business model several times in the past as part of an active innovation process. In this context, the elements target group, value proposition, revenue model and value chain have been fundamentally adapted to address changing market and customer requirements.			Select
SMART SERVICES & PROCESSES								
Are value-added services based on information offered (in addition to shipping, storage, routing, forwarding)?	The company doesn't have formalized services yet and value-added services are not offered.	Manual value-added services are offered (e.g., packaging, inspection, labeling of goods) to customers. Value-added services based on data are not yet offered as data is not collected.	Value-added services providing information with a low level of detail are, e.g., shipment status, shipment location can be offered. Information to customers is provided manually on demand (e.g., via e-mail). Information from internal systems can be retrieved directly (e.g., order status), while information from third parties is still requested manually.	Entities along the supply chain (e.g. suppliers, partners) are integrated and data is captured at all steps of the process (e.g. via labels, sensors) which enables different value-added services. Relevant information in a sufficient level of detail can be provided to customers on demand in real time (e.g. current status, location and condition of shipment).	Customers are offered various value-added services where detailed information about event-offset relationships is given, i.e. which reasons and consequences certain events have (e.g. reason for a delay and new expected delivery time).			Select
Can customers see and change (e.g. quantities			Customers can see the status of an order	Customers can see the status of an order	Customers have access to comprehensive information about their orders. They can			Select

Self-Assessment | Annex

Accessibility: Investigate

The score ranges from -2 to a score between L1 and L4 depending on the maximum maturity to be achieved in the respective question. Some questions only go up to level L1 "Visibility", because a higher score is not possible or irrelevant for the respective question. The total score is calculated automatically and can be found in field I1 after all questions have been answered. The total score equals the lowest score across all dimensions, as in the context of digitalization the weakest link defines the system and should thus serve as a starting point to implement use cases and equally progress throughout all areas and departments of a company. Finally, the result can be used to identify the next steps and value-adding use cases for the transformation to Logistics 4.0 in conjunction with the according roadmap for the logistics services providers or the manufacturing and trading industry.