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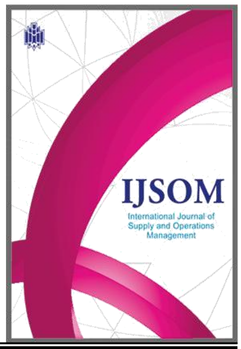

Integration of New Business Models in Smart Logistics Zones

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Abstract

This paper is dedicated to the core challenge of sustainably integrating new and viable business models into logistics systems in the context of the digital transformation. On the one hand, enterprises are facing increased competitive pressure and growth gaps in their own product portfolio; on the other hand, new technology and system solutions are finding their way into enterprises. These new solutions lead to significant changes in the cost structure as well as in the process design. Especially in increasingly digitalised and automated economic sectors such as logistics, production or processing industries, the adaptation and development of the own business model requires a systematic approach that presupposes the use and integration of proven methods. In the context of designing Smart Logistics Zones the interaction of logistical objects, processes, systems and the physical and digital infrastructure is achieved in a goal-oriented manner, depending on the requirements and the situation. An interactive design of the future of human-technology organization takes places. The procedure of the Smart Logistics Zone should support entrepreneurial decision processes purposefully and on the core idea of an Industry 4.0 in preliminary way. In addition to the integrative research concept, this paper focuses on the application of the methodological approach to a reference scenario of the Smart Logistics Zone and an exemplary business model.

Keywords: smart logistics zone, digital transformation, logistics 4.0, IoT, business model, business model innovation.

1. Introduction

With its technological and data-driven components, the digital transformation of the industry has a direct influence on the orientation of production and logistics processes within companies as well as in entire company networks. The development, integration and interaction of new technologies is increasingly dissolving rigid corporate structures and control architectures. The vision ranges from decentralized networks of modular conveyor and storage technology to the application of autonomous transport units, which realize an optimized operational flow based on methods of artificial intelligence (especially machine learning). The lasting success of an enterprise is no longer ensured solely through process and product innovations (e.g. through the creation of a new, technology-based value creation culture), but rather through the additional realization of business model innovations within the enterprise and beyond its corporate boundaries.

The business model must be continuously analysed, taking into account the market environment (external factors) and the company's own performance (internal factors). A holistic view of the business model level in connection with the value creation level (see Figure 1) provides long-lasting potential benefits for enterprises. This can happen in many ways, for example through the identification of new sources of income, a more efficient design of process chains (cost structures), the addressing of new customer markets (customer and sales relations) and the expansion of the product portfolio, e.g. through digital service offers (key activities).

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In turn, by means of the business model, the framework for the essential revenue model as well as the value-creating activities are designed, primarily shaped by the type of organisation (forms of production, network organisation, etc.) as well as the vision, mission, value proposition and corporate culture. The use of data and technologies plays a significant part in the alignment of the business model. The digital transformation in enterprises can be achieved in many different ways, e.g. through the integration of new technology solutions or through simpler activities such as the substitution of analoge processes with digitalized processes e.g. by using ESL-Tags (Electronic Shelf Labels) instead of paper.

In the context of new technology solutions, industrial and commercial enterprises are facing high investment costs, whereby a complete implementation of technology concepts usually does not take place immediately (Helmke, 2019). In most situations, existing plants or processes are successively digitally expanded, adapted or substituted. As a result, different forms of automation and digitization interact within workspaces. Cyber-physical systems (CPS), whose actions are based on algorithms and data structures, combine with human emotional decision-making and action patterns. This human-technology organisation must be designed in such a way, that a functioning working environment is created. In this environment, different technical facilities and the human factors interact directly with each other in a way that is as efficiently as possible as well as it is oriented to the needs and situation.

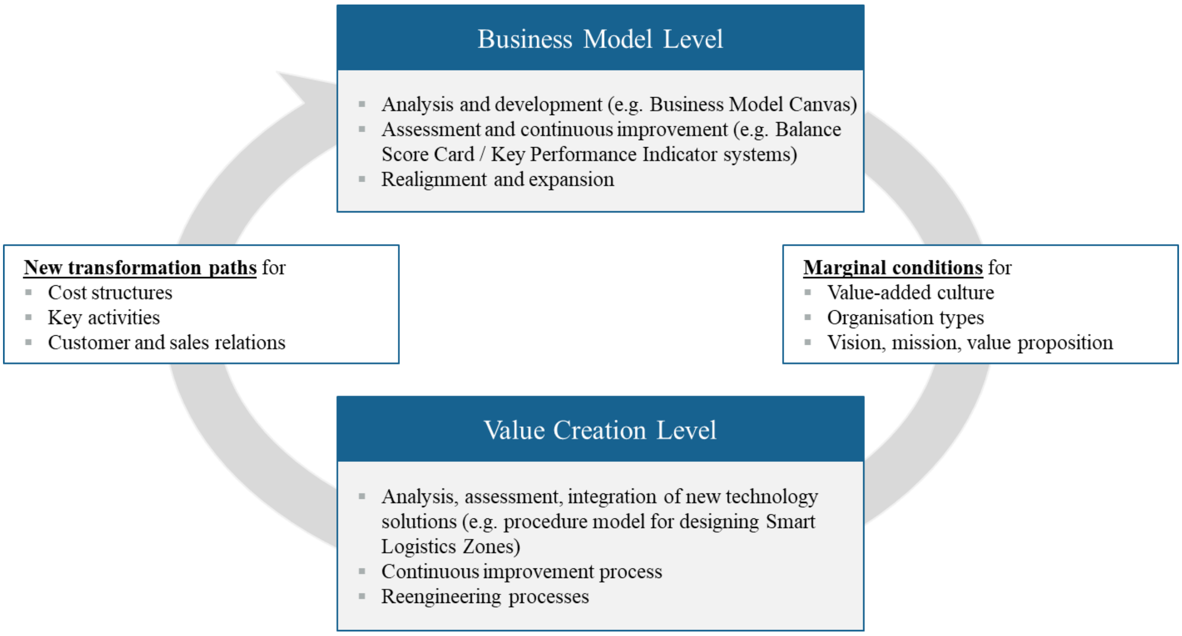


Figure 1. Interaction between business model and value creation level

There is a need for the basic logistics tasks (in the sense of the "8 R Factors of logistics" – provide the right object, in the right quantity, in the right place, at the right time, at the right cost, in the right quality ecologically right and with the right information) (Illés et al., 2007) as well as to consider the requirements to be met from an expanded business model perspective. Figure 2 shows that the information in Logistics 4.0 does not only appear as a logistical object itself, but also as an object and process accompanying it, which makes its use for process control and optimization clear (Arnold et al., 2008). By linking the flow of material and information, the logistic object is enabled to act independently and to coordinate its operations independently (ten Hompel and Henke, 2017). The starting point for Logistics 4.0 and the corresponding new business model innovations is therefore comprehensive information availability at all levels of logistics systems. Self-optimization takes place through inferences from the recorded data with the aim of a quick and flexible adjustment to a volatile environment (Günthner et al., 2014).

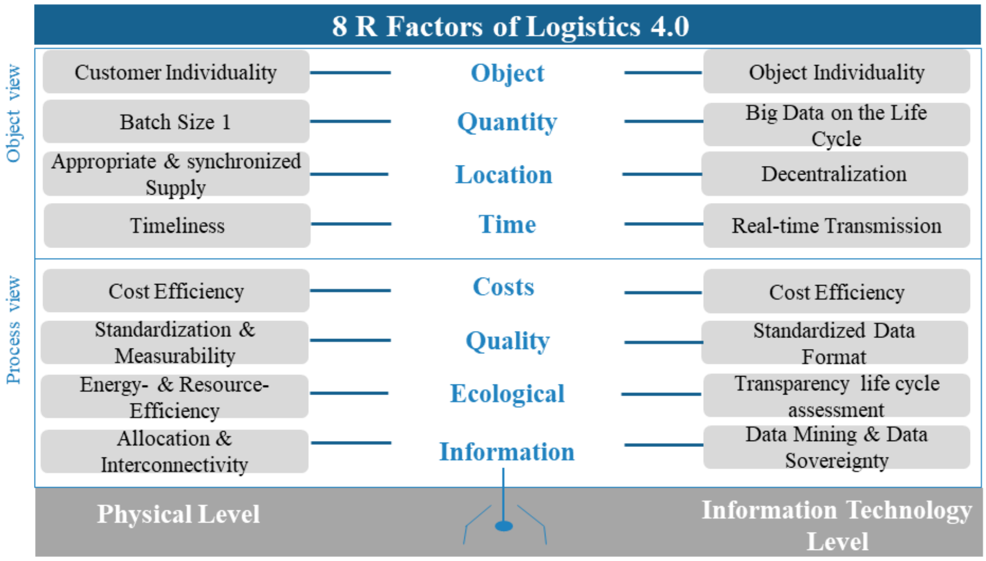


Figure 2. Consideration of the "8 R Factors of Logistcs 4.0" (Schmidtke et al, 2018)

The main approach is to initiate a successful implementation through new suitable technology concepts and methods, so that the logistical functions can continue to be ensured according to their requirements, has been discussed in (Schmidtke et al., 2020). The procedure model for designing *Smart Logistics Zones* provides a methodical framework for the goal-oriented interaction of the logistical systems, processes, objects and infrastructures involved. While the focus in that context was on the analysis and the assessment of different technology solutions (morphology for technology selection including the. development of key figures / application of a QFD matrix), the focus in the following paper is on the specifications and interactions of technology-based business models.

2. Smart Logistics Zone and Business Model Development

In the course of digitalization, logistics is experiencing a reorientation of organizational and technological characteristics, which holds a high economic potential for companies. The development components shown in Figure 3 provide an overview of the new possibilities that emerge in the design of (partially) automated to autonomous logistics solutions in a *Smart Logistics Zone*. With regard to the logistics infrastructure, globalization is leading to a worldwide distribution of logistics and production locations, the prerequisites of which are networked, demand-oriented resource planning and control. The complexity of customer needs requires a flexible alignment of logistical processes and open communication along the entire supply chain (SC), which can be realized through appropriate operating platforms (e.g. IT cloud infrastructures as integration platforms for distributed CPS and smart service applications). The introduction of new technologies in the manner of Industrie 4.0 leads to the automation and (partial) autonomization of production and logistics processes, which at the same time lead to an increase in complexity at the control level due to decentralization. There is an increasing discussion of the potentials of a decentralization of decision-making up to a self-organizing, self-learning control algorithm of the logistics operators, as in (Gronau and Theuer, 2011). The localization of logistics objects has long been the rule in process chains. Nowadays, the combination of predictive detection of object behaviour and adaptation of state variables is increasingly becoming a decisive success factor (Richter et al., 2015).

The interaction of the logistical levels of consideration and the resulting business models is constantly evolving within the context of Industrie 4.0. While traditional revenue models are increasingly complemented by data-driven services, open business models are also becoming prevalent, in which companies can work with partners and suppliers to provide new products, services and offerings outside of their own competencies. The development towards Industrie 4.0 and Logistics 4.0 promises an increasingly sustainable (in the sense of the economic, ecological and social dimension) and resilient (in the sense of flexibility, anticipation and learnability) orientation of corporate structures. In the context of new business model innovations, new value creation opportunities are added, and these are made possible by the integration of new technologies (see Figure 3).

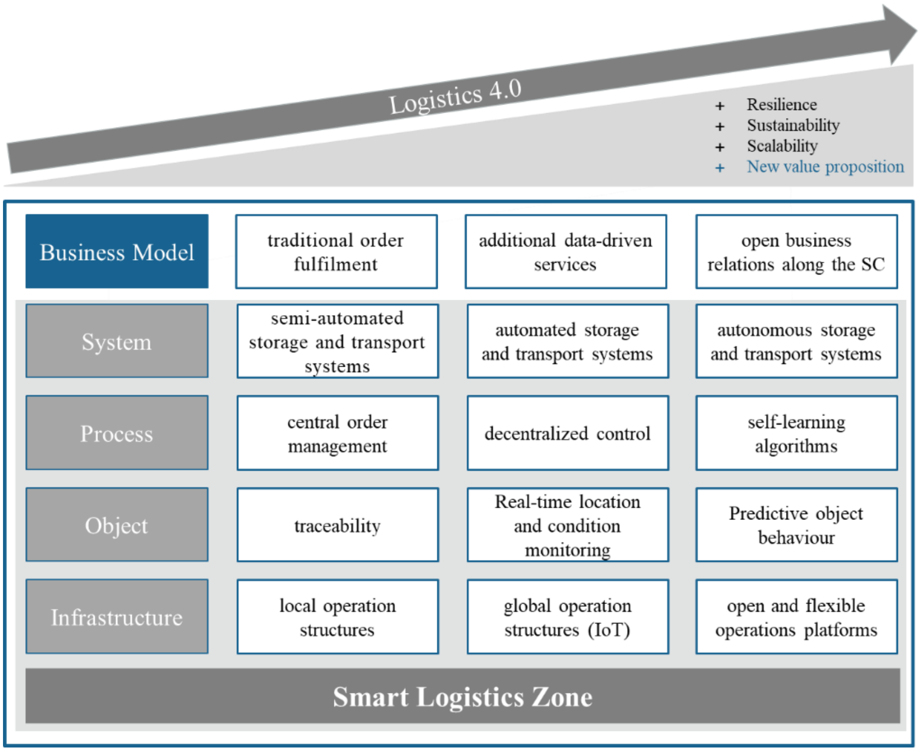


Figure 3. Development components of the *Smart Logistics Zone*

Regarding the criteria system, process, object and infrastructure, the design of the *Smart Logistics Zone* can be carried out in detail according to the specific needs of the company. The challenge lies in determining the desired and necessary degree of intelligence and autonomy in the overall concept. The *Smart Logistics Zone*, as a methodical approach, defines the solution zone at these points and determines a goal-oriented result (Schmidtke et al., 2020).

In the future, in order to implement the requirements of digital transformation in a goal-oriented manner, new approaches and methods are needed to analyze, evaluate, plan, control and regulate logistical and entrepreneurial processes. Classical methods of logistics system planning are gradually reaching their limits (see chapter 3); an integrative view in connection with the most important elements of the associated business model rarely takes place. An integration of new technologies by a continuous recombination of business model patterns can uncover the not immediately visible optimisation potentials in individual segments and instrumentalise the transformation and innovation process. The economic dimension of business models is often considered separately from the technological possibilities. The technological lead enables beneficial effects at the strategic level that are difficult to recognize or implement without a self-sufficient interaction between business model and technology.

In addition to the interaction of logistics objects, processes and systems, the (logistics) infrastructures involved are becoming increasingly important. These infrastructures are equipped with sensors and communication technology to provide new information sources and paths that progressively interact with CPS, e.g. autonomous transport systems.

This is where the procedure model of the *Smart Logistics Zone* sets in, providing an approach and a method portfolio (Schmidtke and Behrendt, 2019) to identify and integrate the requirements of digital transformation into existing logistics concepts (Hompel ten, 2017). The primary aim of the procedure model (see Figure 4) is to determine at which points in the logistics chain there is a need for action with regard to the individual logistics goals of a company (*I. Definition phase*). In doing so, needs-based objectives are formulated using the ‘SMART’ criteria (specific; measurable; achievable; reasonable; time-bound) and taking into account the technological and organisational conditions. *Logistics zones* (*II. Analysis phase*) are identified and expanded by analyzing the characteristic structure of the logistical levels of consideration (system, process, object, infrastructure). Considerations are made from both the physical (material, machine, process) and information technology (data) perspective as well as from the energy and financial perspective. A technology morphology (*III. Design phase*) shows possibilities to change, combine or develop logistics solutions as well as to apply best-practice solutions or to digitize existing solutions. Through the creation of a digital model, a virtual demonstration environment, the performance indicators of logistics including the new assessment categories resilience, scalability and sustainability are improved according to previously defined target criteria and under the performance of a suitability and functional analysis (*IV. Assessment phase*). This is followed by the prototypical implementation of the modified components in the practical application (*V. Configuration/VI. Implementation*). After the successful test phase, series operation can be introduced and a control and regulation of the action sequences and feedback can be validated by the digital model (*VII. Operation phase*). The procedure model is a cycle model, which is anchored by a continuous improvement process in order to implement the goal in the medium to long term (see Schmidtke and Behrendt, 2019 for detailed explanations of the methodology).

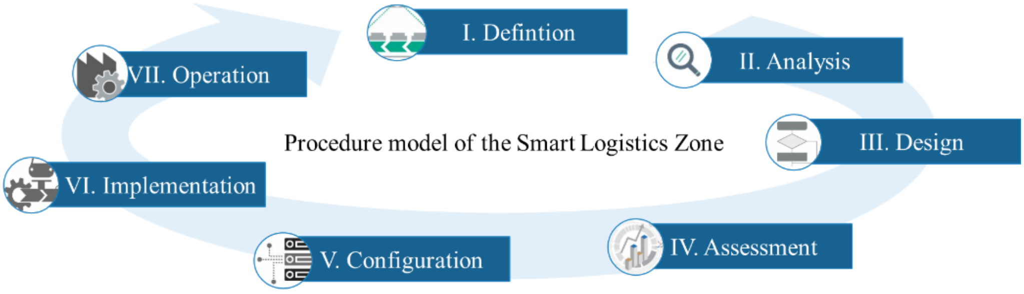


Figure 4. Procedure model of *Smart Logistics Zones* (Schmidtke and Behrendt, 2019)

3. Related Work

3.1 Methodical approach of the systematic literature review

In the following, the necessity and, at the same time, the research gap to provide a methodical framework for the integration of technological innovations into networked logistics zones and impacts on business models will first be pointed out based on an extensive literature review. The approach used in this paper for systematic literature analysis (see Figure 5) is based on the Denyer and Tranfield model (Denyer and Tranfield, 2009). Essentially, the methodological procedure for the literature review from (Schmidtke et al., 2020) is supplemented and continued with additional search criteria. The results from this have shown that classical methods of logistics system planning for technology assessment are reaching their limits. In addition to the classic objective aspects of cost, time and quality, the other objective dimensions (sustainability, resilience, scalability) should also be taken into account. There is a need for a holistic approach to structure transformation by means of key performance figures in order to be able to analyze, plan, assess, control and regulate logistical processes. In addition to the interaction of logistical objects, processes, systems and their technical infrastructure, the effect on the business model level is also foreseeable. The hypothesis of this paper is that a goal-oriented transformation and technology selection on the value creation level as well as on the business model level has not yet been sufficiently discussed in the literature and in the practical application. In this context, the interrelationships between these two levels are examined and systematically interpreted according to the procedure in (see Figure 5).

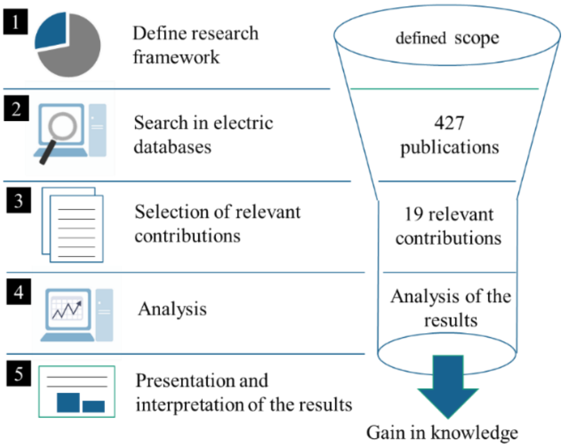


Figure 5. Procedure model of the systematic literature review

In the first step, the definition of the research framework, the definition of inclusion and exclusion criteria as well as the selection of electronic databases takes place. The databases listed below are used due to the high number of published contributions from the logistics and production sector and due to the international degree of name recognition.

Table 1. Used Databases

Used Databases	
ACM Digital Library	IEEE Xplore Digital Library
ScienceDirect	Springer Link

The scope of the study is defined in terms of content as journal articles, books and book chapters as well as journal and conference publications, most of which are written in English. In the context of digital transformation, these have a direct reference to the evaluation of technologies and relation to the business transformation in the logistics or production sector. Furthermore, they can be seen as relevant for the *Smart Logistics Zone*. Further inclusion and exclusion criteria are listed in Table 2.

Table 2. Inclusion and exclusion cirteria

Inclusion criteria	Exclusion criteria
• ocus on contnent in the field of engineering science, in particular the production industry	• Scientific disciplines without direct connection to the field of production science (e.g. medical technology)
• Sufficient quality of paper and possibility of transferability of knowledge	• Paper with very limited insight into the methodological approach (e.g. missing explanatory illustrations)

The second step involves searching in the electronic databases mentioned above. In order to identify relevant publications, the terms listed in Table 3 are used for searches by means of AND and/or OR links.

Table 3. Search terms used

Search terms used	
AND	OR
Technology	Technology Innovation
Business Model	Enterprise model
Production	Logistics
Industry 4.0	Industrie 4.0
Digitalization	Digitization

In the third step, relevant contributions are selected from the filtered publications. The selection is made by reviewing the full text of the contributions. Furthermore, the inclusion and exclusion criteria previously defined limit the selection. The further development of the *Smart Logistics Zone* is an ongoing process, which is linked to a continuous search for relevant contributions. With the help of the search terms used, a large number of publications could already be identified at the current time. Multiple enumerations of the same papers are avoided in the listing.

Table 4. Results of the literature review

Database	publications	selection
ACM Digital Library	11	1
IEEE Xplore Digital Library	120	4
ScienceDirect	180	7
Springer Link	116	7
Total	427	19

3.2 Related work Business Model Development

As shown in Table 4, 19 publications currently meet the previously defined search criteria. These contributions describe the technological opportunities in the context of Industrie 4.0 and digitalization (Dombrowski and Dix, 2018; Wiedenmann and Größler, 2019), and discuss opportunities and challenges at the operational level and, to some extent, strategic business development from the customer and supplier perspective (Cimini et al., 2017). In addition to technological solutions, such as Technology Landscape 4.0 (Wang et al., 2019), structural business transformations at different interaction levels according to RAMI 4.0, individualised product-service systems and platform solutions are addressed and evaluated (Ebi et al., 2019; Stamer et al., 2019). The concept EA framework (Freitas et al., 2019) provides an extended list of attributes that relate technology integration to other business elements. Current approaches in the literature trigger the development of business models, but do not optimise a specific segment in the business model canvas (Osterwalder, 2004; Osterwalder et al., 2005; Osterwalder and Pigneur, 2010).

The need for research on Industry 4.0, digital transformation and its influence on business model innovation, as well as opportunities for the manufacturing industry, are widely discussed in (Ibarra et al., 2018; Johansson et al., 2016; Ibarra et al, 2018; Delsing, 2017). In these approaches, the possibilities of business model development are reflected, but without creating direct relations of selected and/or already implemented technologies to business model transformation. The few studies in this field often implicate only one specific technology (Wiedenmann and Größler, 2019; Sisinni et al., 2019) (e.g. of IoT technology-driven impacts on business models) and show a strong service orientation in business models by integrating internet technologies into the production process. Related work in this context explores the implementation of specific production concepts, such as mass personalization (Torn and Vaneker, 2019) with specific transformational orientations, such as subscription business models (Schuh et al., 2019). Following the progressive development of digital technologies, the described concepts other platform-based business models, and smart or intelligent tools (Zysman and Kenney, 2019) significantly influence economic and social development.

As a further review criterion, besides the technology and business model perspective, the other dimensions (resilience, sustainability, scalability) suggested in (chapter 2) were also examined. Some papers already focus on the sustainability aspects, such as business model closed-loop strategies (Bal and Badurdeen, 2019), sustainable business model (Cornelis de Man and Strandhagen, 2017) concept, illustrated by the business model canvas (Osterwalder and Pigneur, 2010) or sustainability assessment framework on the use case of a supply chain (Valilai and Sodachi, 2020). Whereby there is a lack of a concrete implementation approach for the selection of technologies and their transformative impact on business model segments. For the design of the specific elements of a business model, the patterns of the Business Models Navigator* can be used (Gassmann et al., 2013), but they do not reveal which technologies are relevant for the further development of the business model and how the technology-business model portfolio is linked (Gausemeier and Plass, 2014). Other contributions that represent a primarily technological point of view need to be supported for the optimization of the business model segments. These act merely as enablers in the course of the transformation (Aceto et al., 2019).

This paper shows which optimization potentials arise through systematic technology selection and implementation at the strategic level. In addition, it presents how this transformation can be realized in terms of a continuous improvement of the business model based on specific business model segments (Osterwalder and Pigneur, 2010). In order to identify and meet the requirements resulting from the digital transformation, the *Smart Logistics Zone* approach provides a portfolio of methods (Schmidtke and Behrend, 2019).

4. Methodology

The practice-oriented, methodical approach as a combination of literature review and integration in a technology-business model interaction is tested, and demonstrated on a physical factory simulation model (see chapter 5). The established concepts, the Business Model Canvas according to (Osterwalder and Pigneur, 2010), and the Business Model Patterns as stated by (Gassmann et al., 2013) are used as a framework for the design of the approach. To design the interaction approach (see Figure 6), the first step is to categorize the technologies that are already qualified for the implementation of *Smart Logistics Zones* in (Schmidtke et al., 2020). At this step, technologies such as smart sensors, autonomous robots and cobots, IoT architectures, autonomous vehicles and cloud computing are examined in terms of their integrative impact as enablers for the conception or further development of new forms of businesses. The specifications of the business models act as boosters for the direction of the transformation. They are characterized as innovative disruptors in relation to other dimensions such as resilience, sustainability, scalability, new value propositions (see Figure 3) and technologies. Behind each specification (e.g. business idea) is a creative interaction of the segments at the business model level, which can only be realized due to deliberation (the right selection and implementation of new technologies). Some of these specifications are presented in the following:

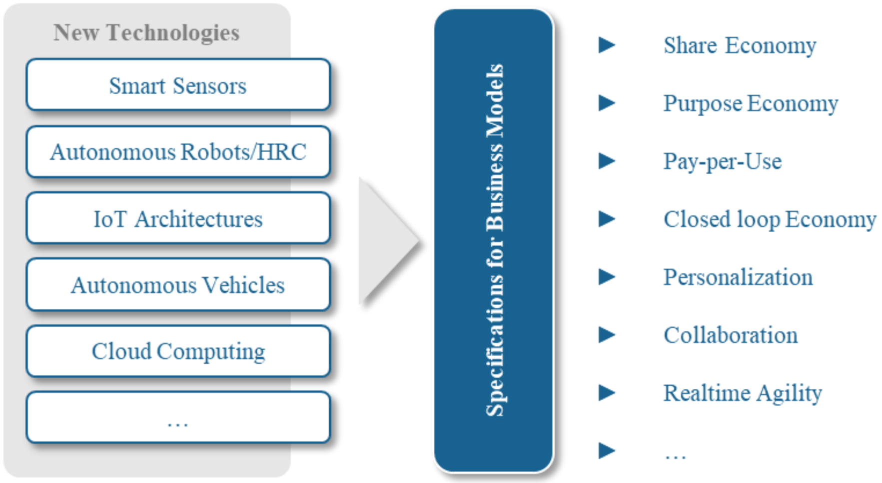


Figure 6. Effects of technology solutions on business models

Share Economy

The revenue-oriented sharing economy encompasses the shared usage of objects (e.g. material goods), but also resources and services. The concept of the share economy is entering the business models of enterprises that provide temporary

* for all 55+ business model patterns see here: https://businessmodelnavigator.com/explore

rights of use for frequently demanded services and goods (Busch et al.. 2018). For the logistics industry, this suggests that the ownership of an object is not a priority, but rather access to it or its service. Furthermore, the resulting relationship with customers, partners or suppliers is paramount.

Purpose Economy

The credible representation of the company's goals and values in order to communicate the purpose of its own products and services as well as differences to previous market players in the global economy. The orientation of the company, which represents social values (e.g. sustainable management from a social, economic and ecological perspective), can influence consumer behaviour. The digital transformation is making markets increasingly transparent, which is raising awareness and creating a need for codetermination among market players and consumers (Bärschneider, 2018).

Pay-per-Use

According to this pricing model, the consumer has the option of using an application (e.g. cloud services) instead of purchasing it. Depending on the usage behaviour, the price-performance ratio, the duration and/or scope of use is determined. Compared to the 'traditional' purchase, the end user saves the one-off investment costs and is committed to individually agreed conditions (Stölzle et al., 2018).

Closed loop Economy

The closed loop orientation of business models aims to improve the long-term effects of entrepreneurial action on society, the environment and the economy in a sustainable manner. The objective is to constantly analyze, evaluate and realign existing concepts concerning resource efficiency, social innovation and environmental impact (Corsten et al., 2018).

Personalization

The company aligns its organisation and processes to the customer. This also refers to as mass customization. In this case, the aim is to meet the different needs of the diverse customer structure and at the same time to increase productivity and profitability in the supply chain (Fogliatto et al., 2012). The focus here is on identifying customer-specific problems and developing individual solutions.

Collaboration

The objective is abouot the collective value generation of partners, suppliers or even customers. By creating synergy effects in closed or open cooperations, new solution concepts are collaboratively developed and new cash flows are generated (Müller, 2018). Digital technologies enable collaboration networks to exchange information constantly and to communicate important process-related data (such as delivery times or production status) in almost real-time.

Realtime Agility

The ability to develop strengths in the company and to instantly recognize and eliminate weaknesses requires agile acting. The company's values (vision, goals and strategy)are anchored in this organisational structure, which should continuously promote organisational adaptability, push innovation and motivate employees to be more engaged by means of an effective leadership style (e.g. under complexity, spontaneity) (Coldewey, 2015). Organisational adaptability through continuous learning and implementation enables the company to be a leading player in the markets.

Table 5. Example of a transformation in business model segments (based on Osterwalder and Pigneur, 2010)

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Proposition</th><th>Customer Relationship</th><th>Customer Segments</th></tr>
<tr><td rowspan="3">- Open source
- Business assistance
- Dynamic Infrastructure
- Virtual assistant
- Swapping
- …</td><td>- Realtime analytics
- Space & work collaboration
- Autonomous Organisation
- Incorporation
- …</td><td rowspan="3">- Realtime analytics
- Space & work collaboration
- Platform design
- Incorporation
- Add-Ons
- Integrator strategy
- Layer Player
- ...</td><td>- Experience
- Virtual Showrooms
- Track & Tracing
- Forecasts
- …</td><td rowspan="3">- Production & Logistics decoupling
- eCommerce
- Platform suppliers
- Self service
- …</td></tr>
<tr><td>- Key Resources</td><td>- Channels</td></tr>
<tr><td>- CPPS, CPLS
- Employees
- Market data
- …</td><td>- Chatbots
- Recognition KI
- Internet
- Social Media
- …</td></tr>
<tr><td colspan="2">Cost Structure</td><td colspan="3">Revenue Streams</td></tr>
</table>

- Crowdsourcing - Price transparency - Use instead of ownership - …	- Licences - Dynamic pricing for additional services - User training - Experience sales - Revenue sharing - …

Through the implementation and configuration of *Logistics Zones* with e.g. smart sensors, autonomous vehicles, as well as the introduction of IoT technologies, new sources and channels of information are created, which provide the foundation for the development or improvement of business models based on data. Following this, it shows that the selection of technologies also directly leads to transformations at the business model level and that an interdisciplinary approach is necessary in this context. The outcome is a business model canvas (based on Osterwalder and Pigneur, 2010) for the systematic transformation of business models, which, in addition to technology, product and process innovations, is meant to highlight new optimization potentials within the interaction between technology and business model. The next step is to derive specific suggestions for action to the corresponding segments from the constraints of the business models. This leads to a creative process for the continuous improvement of business models. As an example, the cloud computing technology, that represents the IT infrastructure (computing power and storage capacity) or the virtual data centre, results in changes in different segments (e.g. real-time analytics, work collaboration, price transparency a.o.) for the business model. For intralogistics, additional optimizations of the business model can result if, for example, objects are equipped with smart sensors. As a result the extension and capabilities of this sensor evolve from simple measurement unit to a cyber-physical system, as a premise for the decentralised control of key resources (autonomous operation, monitoring of environmental parameters) and key activities (autonomous organisation, self-calibration, self-diagnostics).

5. Application of the Use Case

5.1 Preview

The procedure model of the *Smart Logistics Zone* enables demand-oriented and efficient solutions for production and logistics systems by providing a targeted selection of technologies and methods. These range from individual customer integration into the final production stage or delivery through to resource-saving and self-regulating material provision. Through an integrated overall view of the object and process requirements and by considering infrastructural requirements, isolated solutions in *Logistics Zones* can be avoided. This enables a holistic increase in efficiency and quality with a minimal time and lower costs. The logistical objective extends beyond the classic assessment categories such as quality, costs and time to further target dimensions such as resilience, sustainability and scalability. Intelligent logistics solutions will lead to changes in production systems. For example, self-learning control systems that mediate production orders between the actors and promote the dissolution of rigid boundaries and the ability to grow, as well as have a lasting effect on corporate success by integrating social and ecological aspects (Anderl et al., 2016, p. 12). The procedure model of the *Smart Logistics Zone* provides for a preliminary consideration at the beginning of the planning process.

5.2 Introduction of the Use-Case

The procedure model is currently being tested in a test and demonstration environment. As a partial objective of the research project, the functionalities and applicability in practice will be tested at an early stage using the reference scenario shown here. In the *Design* (III.) and *Assessment* phase (IV.), the procedure model presented provides a virtual demonstration environment for the introduction of new technologies, which in this case represent production logistics problems. New technologies and methods can be tested before implementation (see Figure 4).

For the exemplary testing of the process model of the intelligent logistics space, with special consideration of the influence on the business model development possibilities, the automated training and simulation factory 'Factory Simulation 9V' (Fischertechnik, 2016) is used as an object of investigation. The model simulates a miniaturised, fully automated factory consisting of four individual modules that are involved in the overall process:

1. Automated storage and retrieval system (ASRS),
2. Multi-processing station,
3. Vacuum Gripper Robot and
4. Sorting Line with colour detection

In the factory, a simple but typical process of the manufacturing industry is simulated. A product (object) with three variants is stored and retrieved, processed and sorted for dispatch (process). Many core processes of classical logistics, such as transport, handling, storage and retrieval, material provision or order picking, can be found in this process. Because of the modular design, the system offers the possibility of systematic expansion and testing of different technological solution approaches. The system boundary is situated at the interface to the supplier and ends, at the interface to the customer, and is specified in more detail in the *Analysis* phase (II.). At this point, the *Smart Logistics Zone* is understood as an examination and planning room. Based on the model example, a holistic system, its business processes and the underlying business models can be analyzed (II. *Analysis*) and potentials and target-oriented solutions, aligned to specific target criteria, can be developed (III. *Design*). Through the continuous further development to a 4.0 solution according to Figure 3, i.e. increasingly automated, data-driven and networked, holistic process improvements can be investigated by new technologies at the various levels of the *Smart Logistics Zone*.

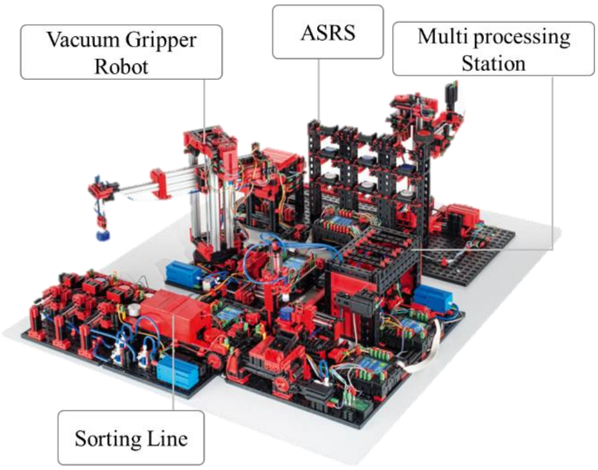


Figure 7. Factory Simulation Model (Fischertechnik, 2016)

5.3 Analysis (II.)

Material flow

At the beginning of the process, the workpiece (object) is transferred by the Vacuum Gripper Robot via a conveyor line to a Storage and Retrieval Machine (SRM) and stored in a container in the ASRS. When the production order is triggered, the workpiece is removed from storage by the SRM and transferred by the Vacuum Gripper Robot to a Multi processing station. This station imitates a machining process by a furnace (e.g. reshaping, joining, coating or altering material properties according to DIN 8580 (2003)) and is then transferred to a turntable via another Vacuum Gripper Robot. This transfers the workpiece to a stationary rotating saw as a last processing step of the Multi processing station. After completion, a pneumatically operated ejector pushes the workpiece onto an apron conveyor. The workpiece is conveyed through a light blocking box in which a sensor determines the colour of the object. Based on this, the workpiece is ejected for goods issue at the corresponding storage location. In the initial model, the workpiece is stored again from here. This cycle is repeated indefinitely. The process sequence is shown in Figure 8.

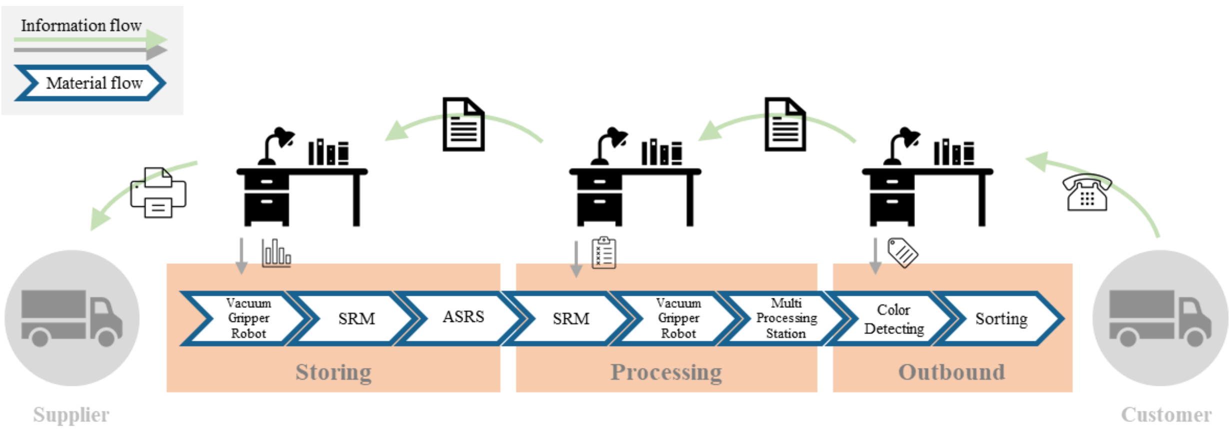


Figure 8. Process model of the reference model 'Fischertechnik Factory Simulation 9V'

The individual components are controlled via local controllers (infrastructure). The Multi Processing Station and the ASRS including the Vacuum Gripper Robot form a control unit with two controllers each, which act in the master-extension network. The Sorting Line with colour detection forms the third control unit.

Information flow

Interaction for customers, internal departments such as production planning, the management level or suppliers is not directly possible. The information flow is detached from the material flow, decentralised and with frequent media disruptions. An order from a customer triggers a delivery order or instructs production, depending on the availability. They have to request the material supply from the warehouse. Depending on the stock levels, further raw parts must be ordered from a supplier.

Problems and objectives

As explained in chapter 2, the objective of the investigations in the *Smart Logistics Zone* is affected by various factors. By examining the business model areas and assessing the current and expected future influencing factors (e.g. positioning in the market, development of customer needs, development of market volume and market shares), conclusions can be drawn about the own global objectives of the business model level (see Figure 1).

In the application example presented, the current value proposition of the existing business model is mainly the processing of raw materials into a finished product (added value share). It is assumed that the customer relationship is often based on existing contacts. Orders are placed either via concluded framework agreements or via enquiries by telephone or E-mail. The required resources (production factors) are ordered directly from the supplier. The existing business model elements are marked separately in Table 8.

In the analysis of the existing business model (‚Business model level‘, see Figure 1), four potential areas were defined in the first cycle of the *Smart Logistics Zone*:

- **Customer Engagement**

  The relationship with the customer should become more straightforward. The customer should be able to specify individual requests directly. In addition, the customer should be able to track the ordered goods in order to be able to draw conclusions for their own scheduling. In this way, benefit can be created, which improves the competitive situation and allows higher prices due to the benefit.

- **Data Transparency**

  The company's own production should become more transparent. Disruptive factors are to be recognised at an early stage. Communication and data transparency between the departments will be uniformly integrated. Through transparency and direct communication, shorter delivery times, quick reactions to changes and the reduction of risks are created.

- **Supplier Engagement**

  Suppliers are to be integrated into the production process. In this way, (emerging) bottlenecks in material procurement can be reported directly to the supplier through an integrated system. The supplier can adjust to orders at an early stage and optimally integrate this information into its own business processes. This is another way to shorten delivery times and minimize sources of error.

- **Extended Value Proposition**

  In addition to the existing value creation through the individual processing steps to a finished product, the physical product can be expanded with digital add-ons. The transfer of additional product information, which is stored directly on the product, not only results in advantages within the company's own processes, but also offers added value for the customer. When the product arrives at the customer's premises, the product information (e.g. ID, colour, batch, manufacturing date, certificates, notes, etc.) does not have to be entered manually into the system, but can be transferred automatically.

The potentials identified form the boundary conditions for the‚Value Creation Level‘ (see Figure 1). The formulated new directions and extensions of the business model level are supplemented by specific objectives.

The formulated objective significantly determines the quality of the solution (Krampe and Clausen, 2006). The objective is concretised by including the classical assessment categories dimensions and those initiated by Industrie 4.0. Digitalization should not be seen as the full automation of a system, but rather as the possibility of networking objects and their self-control in a regulated cycle (Ten Hompel et al., 2017). This justifies a target-oriented technology selection and integration into new or existing structures. Classical assessment categories such as quality, costs and time as well as the new target dimensions of the *Smart Logistics Zone* have to be quantified. The formulation of the objectives is based on the SMART criteria (Doran, 1981). In the context of the procedural system, the following objectives can be described in detail:

- Specific – precise formulation of the desired state.
- Measurable – determine quantitative indicators for the desired state.
- Achievable – analyze feasibility and responsibilities in advance.
- Reasonable – estimate results and benefit.
- Time-bound – schedule for achieving the desired state.

Taking into account the holistic goals of the previously elaborated corporate development, three goals were defined as examples (see Table 6). The goals are specified as precisely as possible, target values are defined in order to make the achievement of the goals measurable through the various measures, so the goals are defined in a way that can be assigned and is as realistic as possible.

Table 6. Formulation of the individual objectives

<table>
<tr><th rowspan="9">Criteria</th><th></th><th>Objective 1</th><th>Objective 2</th><th>Objective 3</th><th>…</th></tr>
<tr><td>Specific</td><td>Shorten lead times (point of order to delivery to customer)</td><td>Transparent delivery process for the customer</td><td>Integrated procurement interface to the supplier</td><td></td></tr>
<tr><td>Measurable</td><td>Reduction of the lead time about 10%
80% availability rate of the ordered products</td><td>Tracking of the four main process steps</td><td>Real-time
Providing quantity and quality</td><td></td></tr>
<tr><td rowspan="2">Achievable</td><td colspan="3">Wifi interface of several TXT controllers
Integrated information system</td><td></td></tr>
<tr><td>Reduce risks by providing environment data of the production process</td><td>Interface/Access for the customer</td><td>Interface/Access for the supplier</td><td></td></tr>
<tr><td>Reasonable</td><td colspan="3">Communication via Machine to Machine and integration of the data. Suppliers and customers are interested in a collaboration.</td><td></td></tr>
<tr><td>Time-bound</td><td colspan="3">Medium-term implementation (one year)</td><td></td></tr>
</table>

5.4 Design (III.) and Assessment (IV.)

In the next step, possible solutions are identified in the *Design* phase (III.) and are then assessed (IV.). Thereby, the formulated goals of the identified business model potentials are integrated on the process level. A detailed explanation of the approach of technology selection in the identified *Smart Logistics Zone* can be found in the publication by Schmidtke et al. (2020).

In the revised process design, RFID technology is used as a basic infrastructure supplement, which is already attached to the raw goods (object) upon delivery. At a newly created delivery station, the colour of the delivered product is detected and stored (together with other relevant information) on the RFID chip using Near Field Communication (NFC). Another process modification occurs at the newly added pick-up station where the goods are made available to the customer. Again, the product information on the RFID chip is supplemented with further production data (see Figure 9).

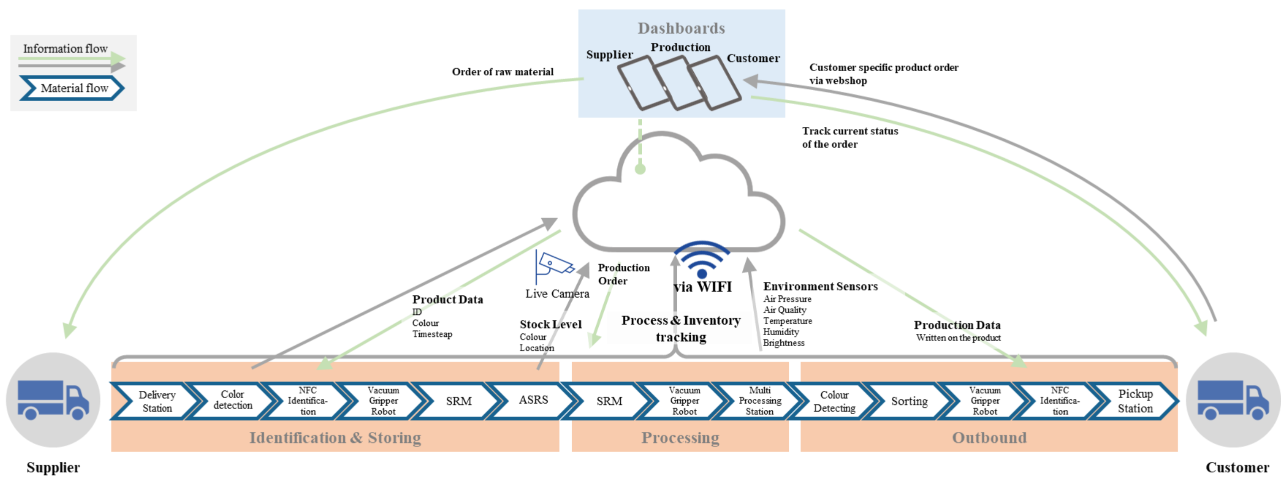


Figure 9. Process model of the improved reference model 'Fischertechnik Training Factory Industry 4.0 9V'

The transformations of the initial model on the system, process, object and infrastructure levels are shown in Figure 3. The expansion possibilities of the business model are considered separately in the following chapter.

Table 7. System, process, object and infrastructure transformation through IoT technology deployment

	Initial Model	**I4.0 Technology Extension**
System	Production system with automated high-bay warehouse, multi-processing station, vacuum gripper robot & sorting line with colour detection	Extension of the production system to include a delivery and pick-up station, as well as the possibility to interact with suppliers and customers.
Process	Storage, retrieval, processing, sorting	Extension with delivery and pick-up station incl. RFID reader
Object	Workpiece in three possible variations	Storage of data on the object
Infrastructure	Control via local controllers, information flow detached from material flow	Extension with RFID technology, IoT structure and Cloud connection

In addition, the controllers within the factory are interconnected and communicate via MQTT (Message Queuing Telemetry Transport). The integrated WLAN router enables connection to a cloud via the Internet of Things and Services (IOTS). This is where all the status messages are collected and interaction options with the various components are provided. The information is provided in three different dashboard views.

By assigning different user roles, the data can be made available in a targeted manner and offer individual benefit to the different roles. A supplier can be given the opportunity to track which product is ordered and in what quantity. A customer can order products directly via a web interface and thus trigger a production order. Through integration into the production system, the availability of products can be displayed in real time. In the production view, the progress of the production process can be visualised and the status of the individual components can be displayed. This enables the user to recognize a failure of the real system at an early stage by a message of the Digital Twin. Furthermore, stock levels can be displayed in real time, as well as various environmental data within the factory (e.g. air pressure, air quality, temperature, humidity and brightness) and their course over time. Live cameras can also help to monitor the system, processes, objects and parts of the infrastructure. The dashboards of the Smart Factory are shown as an example in Figure 10.

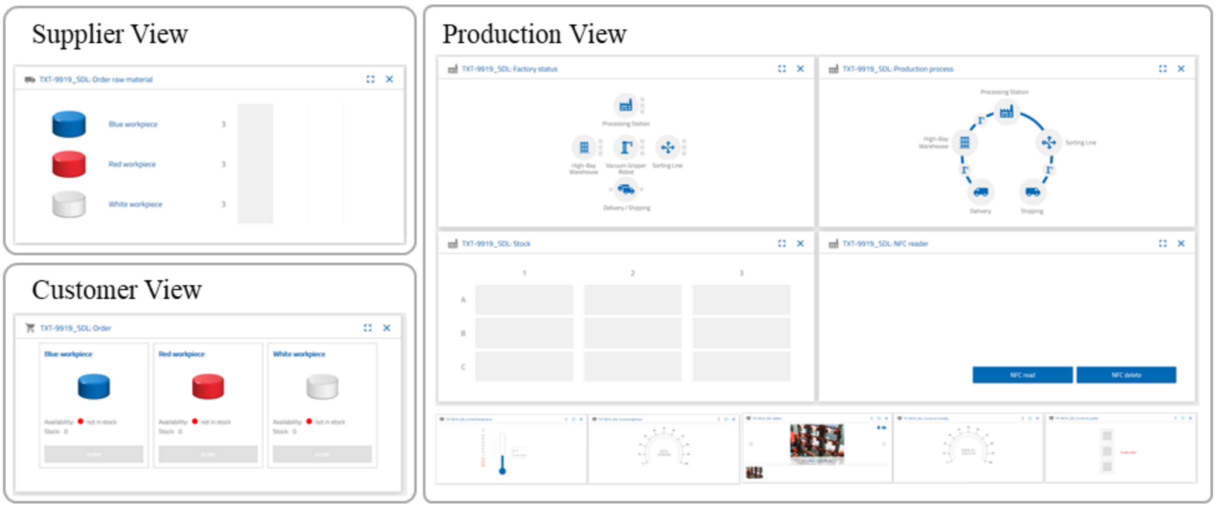


Figure 10. Supplier, Customer and Production Dashboard (Fischertechnik, 2016)

5.5 Business Model potentials

The newly implemented technologies, which complement the existing structures in the *Smart Logistics Zone*, have various effects that influence the business processes and the business model. For example, the use of smart sensors, their networking in the form of an IoT archtitecure, as well as the possibility of interaction via cloud computing enables the specification of the business model.

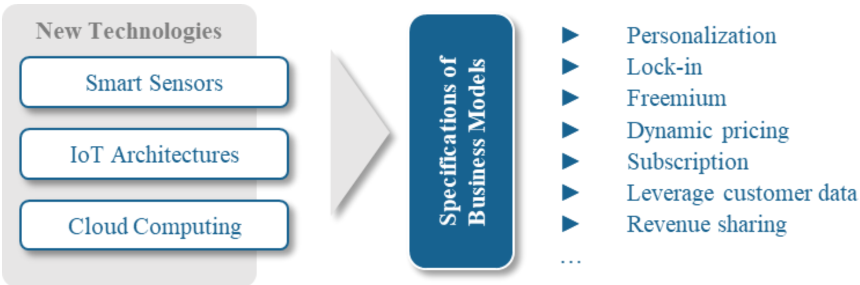


Figure 11. Application Scenario: Use of new technologies allowing new specifications of the Business Model

Osterwalder et al. (2010) offer a clear and intuitive way to present the different elements of a business model. Table 8 shows individual changes to the business model in the corresponding areas. This shows the advantage of the cyclical approach of the *Smart Logistics Zone*. On the one hand, the use of new technologies can generate immediate advantages at the various levels of the SLZ, and on the other hand, the prerequisites for further development potential can already be created.

As the core of the business model, the value proposition of the classic processing of raw materials into a finished product can be expanded with digital offers. The customer perceives the transparent possibility of interaction, the knowledge of the availability and status of an order as a benefit and improves the competitive position of the producer. In addition, the data on the RFID chip of the product enables the customer to integrate the data tag into their own processes, e.g. for automated goods receiving. The information on the RFID chip can be precisely adapted to the customer's requirements and their processes (*'personalization'*). This creates the possibility of a '*lock-in'* effect, whereby the customer could only change providers at high switching costs.

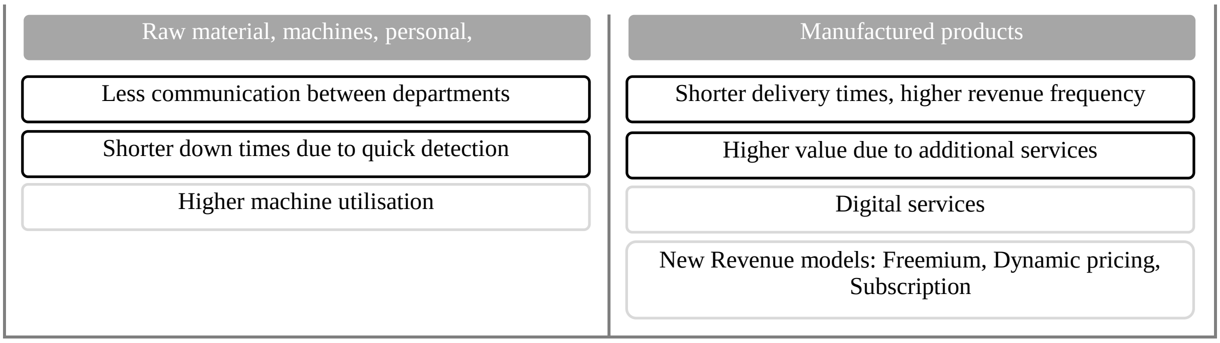
As decribes above, the relationship with the customer becomes more personal and at the same time more efficient. This also creates further value-added opportunities. Through direct contact with the customer, further documents, such as design files, animations or manuals, can be made available. Various new sales models are conceivable here. For example, some of the services can be made available free of charge, while other services are only available at an additional price (*'freemium'*, see Anderson (2009)). The product information can be accessed easily via the web interface. This creates new possibilities for appealing product presentations, e.g. through videos, virtual reality (VR) or reviews by other customers. New customers can thus be addressed more directly. Further customer-specific customization requests can be created in the future through the possibility of interaction and thus position the company more broadly and open up further market segments. Various pricing models such as *'dynamic pricing'* (Reinartz, 2002) or '*subscription'* (Schuh et al., 2019) are conceivable. Furthermore, the customer (usage) data obtained (e.g. ordering behaviour, target group analysis) is another benefit that can be used for the company's own process and product improvements, or can be offered to other companies in anonymised form (*'leverage customer data'*).

In order to be able to offer additional value propositions, the key activities and processes, as well as the integration of suppliers, are also changing. The Cyper-Physical Production System (CPPS) that has been created enables real-time monitoring of the processes and thus rapid recognition and intervention in the event of faults in the plant. Longer downtimes due to disruptions can thus be reduced. By sharing information along the value chain, communication between the individual departments and partners is more effective, thus saving costs and reducing errors. The digitalization of all order data and the recording of the machines' condition also enables the use of AI in production planning (Lang et al., 2021) or predictive maintenance (Henke et al, 2020; Permin et al., 2019). In addition, it is conceivable to open up the close networking with one's own key partners as a platform and thus act as a transmitter between customers and providers. By controlling the platform, one's own business model can be supplemented. Through *'revenue sharing'* or other remuneration models, a further revenue stream can be generated.

Table 8. Application Scenario: Direct and enabled future impact on the Business Model

Existing business model elements	Direct impact	Future impact enabled

Key Partners	Key Activities	Value Proposition	Customer Relationship	Customer Segments
Key suppliers	Production Processes	Processing raw material	Contracts, personal contacts	Various customers
Real time orders via web system	Real time monitoring	Data attached to the product	Display of Product information	Easy access for new customers
Offering a platform structure	Predictive maintenance	Availability tracking	Direct relationship	Personalized products
Shop-in-shop	Data Analytics	Process tracking	Digital product presentation	
	Autonomous decisions	Faster delivery	Lock-in effect	
	Key Resources	Further document sharing	**Channels**	
	Machinery, skilled worker	After sales services	Sales Processes	
	CPPS	Leverage customer data	Direct interaction via Web interface	
	Matrix production			
	AGVs			
Cost Structure			**Revenue Streams**	



The monitoring of the process status, all production-relevant data, as well as the decentralised storage of data on the product also opens up further possibilities. These further possibilities can include new process flow structures, such as the integration of further machines in the form of a matrix production as a new form of production organization, as well as further technology connections, such as AGVs.

In a matrix production system, the manufacturing stations are freely interconnected through AGVs. This leads to a complex control structure, which means that all information must be available for production planning in order to be able to use all the advantages to optimality. The advantages are numerous, such as the combined use of resources, shorter transport routes compared to value-added-oriented productions or short intermediate storage. (Greschke, 2016)

By using RFID tags, the use of AGVs could be analyzed in the reference example as a connection to the delivery and pick-up station in the next SLZ cycle. The data interface between AGVs and the production system is directly given by the transfer of data by means of the workpiece (object).

6. Conclusion and Outlook

The process model of the *Smart Logistics Zone* represents a new perspective for the analysis, planning and evaluation of logistics systems as well as considering practical methods and technologies. In this case, the focus of the paper is on the procedural steps of the *Analysis* (II.), *Design* (III.) and *Assessment* (IV.) phase.

The process model was illustrated by using an example of a production and intralogistics concept based on two versions of the Fischertechnik Training Factory model. By combining the method of the *Smart Logistics Zone* with a new approach of business model development, new relationships as well as revenue models and communication models can be developed. Through comparison of the two Fischertechnik models (see Figure 8 & Figure 9), the authors were able to show which new business models could be developed and implemented by integrating IoT and Industrie 4.0 technologies.

The connection between the requirements and functions of the material flow and the evaluation of the system effects by key figures enables a comprehensive consideration of the possible solutions. This leads to a comprehensible, well-considered and precise selection of solutions. The reference scenario (see Figure 8) considered here serves as a starting point for estimation of the method and its potential use. As a next step, the initial scenario will be enriched with real data of companies, in order to be able to prove the functionality of the method. Afterwards, the application of the new technologies will be simulated and evaluated.

In the presented work, it is shown that in the context of digital transformation, a cyclical approach, as presented in the *Smart Logistics Zone*, is advantageous. Companies face the challenge of understanding different technologies and solution approaches to be able to prioritise them. Digitisation, automation and the use of Big Data within production and logistics with new technologies affect many different levels of a company (business model, system, process, object, and infrastructure). It is helpful in this respect not to view this challenge as a binary problem that can be solved with a one-off investment, but to approach it with a holistic and long-term view. Using the example of business model development, it can be shown that the gradual introduction of new technologies on the one hand immediately creates added value at various levels (e.g. live tracking through RFID), and on the other hand only their introduction enables further development potential (e.g. personalization).

There are also plans to develop new business model approaches for intralogistics and production organisational issues. For this purpose, there are initial considerations to design and implement new approaches e.g. in production organization with a special issue on adaptability, such as concepts like matrix production systems (Greschke, 2016; Schmidtke et al., 2021). With the help of the concept of the *Smart Logistics Zone*, new business model approaches could be designed.The focus of further research is to expand the current reasearch to include the topic of sustainability. The ‘Fischertechnik Training Factory Industry 4.0 9V’ model offers the first technical solutions for this. By integrating environmental sensors, for example, which measure temperature, air composition or light intensity, new key figures can be continuously collected and evaluated. By integrating this sensor information into the concept phases of the *Smart Logistics Zone*, new business model variants can be developed for customers in the future, making it possible, for example, to select different manufacturing processes based on their carbon footprint.

Similarly, the ‘Fischertechnik Training Factory Industry 4.0 9V’ model could be extended to include the collection of end-to-end identification, change-of-state documentation and tracking in the sense of Industry 4.0, so that the NFC chip and thus the product tracking can be rewritten at all stations and independently send status information to the cloud as an IoT solution. This would increase object transparency and enable a further step towards an end-to-end CPPS/CPLS.

In terms of a continuous supply chain, there are also efforts to connect the ‘Fischertechnik Training Factory Industry 4.0 9V’ model with an ERP system and thus to ensure an integration into the PPS architecture and to enable an exchange of information via defined interfaces and to enable new forms of collaboration within the supply chain.

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