



Agile methods used by traditional logistics companies and logistics start-ups: a systematic literature review[☆]

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ABSTRACT

An increasing number of companies and start-ups aims to enhance their agility through the use of agile methods and practices in order to cope with raising product development and project complexity and quickly changing requirements (Laanti et al. (2011); Schön et al. (2017); Könnölä et al. (2016)). Especially in the logistics industry, which is known as a slow adaptor to changes in general but regarding new innovations in particular (Cockburn and Highsmith (2001); Beck (2000); Abbas et al. (2008)), it is relevant to see how these companies cope with change. Opposed to that, logistics start-ups seem to be able to create customer value with disruptive products and services. This paper aims to capture the current state of the literature related to the use of agile methods and practices in established logistics companies and logistics start-ups. Of particular interest will be analyzing which methods and practices are used, what specific challenges established logistics companies and logistics start-ups aim to solve with these agile methods and practices, and the difficulties they face in doing so.

A systematic literature review (SLR) with an extensive quality assessment of the included nine studies was conducted. After the analysis, insights on the following points were derived: use of agile methods and practices, the challenges that are solved with these methods and practices, and difficulties in the application of these methods and practices.

Future research should deepen these findings with, for instance, qualitative data from real-life cases of logistics companies and start-ups. The originality of the SLR presented lies in its contribution to the largely unexplored field of agility in traditional logistics companies and logistics start-ups, as well as its assessment of the state-of-the-art literature analyzed.

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1. Introduction

Digitization is increasing the demand for software products such as platforms and (mobile) applications, even for industries that have not (predominantly) made money with software products in the traditional sense. It is therefore important to observe whether other industries, as in the case of this study the logistics industry, cope with this demand for software products. This rises the question whether logistics companies use agile methods to digitize their products and align them in the best possible way to the customers' needs.

Over the last years the use of agile methods and practices has increased in importance, not only for software companies (Laanti et al., 2011; Schön et al., 2017; Könnölä et al., 2016). Agile

methods and practices such as Scrum and Kanban are used to cope with rising product development and project complexity, rapidly changing customer expectations, business model insecurities, complex technological decisions or other shifting external influences occurring, as with a corporation's suppliers (Cockburn and Highsmith, 2001; Beck, 2000).

Agile methods and practices promise to deliver business value on time and in short iterations, which allows for a process that is carried out incrementally and empirically, and enables immediate changes (Abbas et al., 2008; Larman and Basili, 2003). The concept of agility itself has evolved from comprising flexibility and leanness to a value-driven concept since the 1980's (Conboy, 2009). Agility focuses not only on customer value, but also on people, communication and collaboration to be able to achieve flexibility and leanness (Conboy, 2009; Campanelli et al., 2018; Campanelli and Parreiras, 2015).

Today, the concept of agility still is a multifaceted concept and is interpreted in research and practice in many different ways (Conboy, 2009; Dingsøyr et al., 2012). Since agility focuses

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on humans and interactions it depends heavily on the mindset of all employees (Chow and Cao, 2008; Kropp et al., 2020; Jovanović et al., 2017) and promotes the rapid implementation of user-centric solutions (Beck et al., 2001). It is particularly important to understand how the conservative logistics industry – which is known as a slow adaptor (Kupp et al., 2017) – copes with agility, and how established logistics companies and logistics start-ups use agility to deliver innovative products that customers appreciate (Vogel and Lasch, 2018; Luz et al., 2019).

Many logistics companies seem to have difficulties delivering the appropriate customer value, and that gives the impression that they cannot keep up with start-ups in doing so, or with the speed of innovation within the industry (Beck et al., 2001; Newkirk, 2002; Delfmann et al., 2018; Bugert and Lasch, 2018). Therefore, the question is: which agile methods and practices that focus on customer value are used by logistics start-ups, and how do they compare with those used by more established companies?

The intention of this systematic literature review (SLR) is to investigate how other studies describe the use of agile methods and practices by traditional logistics companies and logistics start-ups. Relevant methods and practices are based on agile software development methodologies; thusly, approaches like the agile supply chain are not the main target of this SLR. Whether traditional logistics companies and start-ups use the same methods and practices will be the focus of the investigation, as well as which problems they want to solve with these methods and practices and what challenges they face.

The aim of this systematic literature review is to:

- Clarify the state-of-the-art developments in the field of the application of agile methods by traditional logistics companies and logistics start-ups.
- Determine where the research fits into the current body of knowledge.

The contribution of this SLR presented lies in its:

- Addition of knowledge to the largely unexplored field of agility in traditional logistics companies and logistics start-ups.
- Assessment of the state-of-the-art literature analyzed.

The SLR is conducted based on the guidelines from Kitchenham and Charters (2007), Brereton et al. (2007) and Wohlin (2014).

Based on the findings from the SLR, a theoretical framework that explains when and how traditional logistics companies and logistics start-ups use agile methods and practices will be deduced.

The paper is structured as follows: Section 2 gives a brief overview of the development and the context of agile methods and practices, including a gap analysis of related work. Section 3 presents the research objectives, the research questions and describes the search strategy, selection process, quality assessment, data extraction and data analysis. Section 4 summarizes the general findings of our study as well as an overview of the included studies to answer the research questions. Finally, Section 5 discusses the findings and limitations of this paper. Section 6 concludes this study and provides some perspective for future research.

2. Background of agile methodologies

Since the 1980's, the concept of agility has evolved from comprising flexibility and leanness to a value-driven concept (Conboy, 2009; Stavru, 2014). Agility focuses not only on customer value, but also on people, communication and collaboration to be able

to achieve flexibility and leanness (Conboy, 2009; Aldave et al., 2019). Today, the concept of agility still is a multifaceted concept and is interpreted in research and practice in many different ways (Conboy, 2009; Jalali et al., 2014). Conboy and Fitzgerald provide a general definition of the term and describe agility as “the ability of an entity to proactively, reactively or inherently embrace change in a timely manner, through its internal components and its relationships with its environment” (Conboy and Fitzgerald, 2004; Sarker and Sarker, 2009; Lindsjörn et al., 2016; Pikkariainen and Wang, 2011; Dikert et al., 2016, p. 39). They thus describe the basic values of agile process models, above all willingness to change and cooperation (Cohn, 2009). Qumer and Henderson-Sellers deepen this definitions with the facets of agility such as “nimbleness, suppleness, alertness, responsiveness, swiftness and activeness” (Qumer and Henderson-Sellers, 2006, p. 122). Different other authors use the attributes flexibility, speed, leanness, learning and responsiveness (Conboy and Fitzgerald, 2004; Wong and Whitman, 1999; Boehm and Turner, 2003). In this work agility will be understood as a concept that aims to achieve the attributes flexibility, speed, leanness, learning and responsiveness through the ability to proactively, reactively or inherently deal with change quickly.

Agility is not exclusive to one functional area but “can be addressed in different business competence areas”, such as (see also Fig. 1) (Kettunen, 2009):

- Business agility
- Enterprise agility
- Agile organization
- Agile manufacturing
- Agile supply chain
- Agile software development

The concept of agility was first introduced in organizational theory and social science as corporate agility, to respond effectively to changes in an uncertain world. Brown and Agnew described agility as “the capacity to react quickly to changing circumstances” in 1982 (Brown and Agnew, 1982). They mention not only flexibility but also commitment of key resources, mainly human resources to output-oriented goals (Schirrmacher and Schoop, 2018). The application of agility was concretized in the Lehigh Report describing agile manufacturing, which was published in 1991 (Hooper et al., 2001; Nagel and Dove, 1991). Hooper describes agile manufacturing as a “manufacturing system with extraordinary capabilities (internal capabilities: hard and soft technologies, human resources, educated management, information) to meet the rapidly changing needs of the marketplace (speed, flexibility, customers, competitors, suppliers, infrastructure, responsiveness) (Yusuf et al., 1999; Davarzani and Norrman, 2015; Mourtzis, 2016). In 1995, Goldman et al. extended the Lehigh Report and stated that agility is relevant for other organizational units as well, such as marketing, production, design, organization, and management. Goldman et al. describe agility as “a comprehensive response to the business challenges of profiting from the rapidly changing, continually fragmenting, global markets for high-quality, high-performance, customer-configured goods and services” (Goldman et al., 1995). The uncertainty of changing requirements also affects IT and software development, where the need for agility also increases due to the dynamic circumstances of the other business and technological areas mentioned before. In 2001 the so-called “Agile Manifesto” of software development projects was introduced (Beck et al., 2001), after agile and iterative process models like *Rational Unified Process* and methodologies like Scrum and Extreme Programming (XP), Feature Driven Development and Kanban had been developing since the 1980's (Beck, 2000; Takeuchi and Nonaka, 1986; Schwaber,

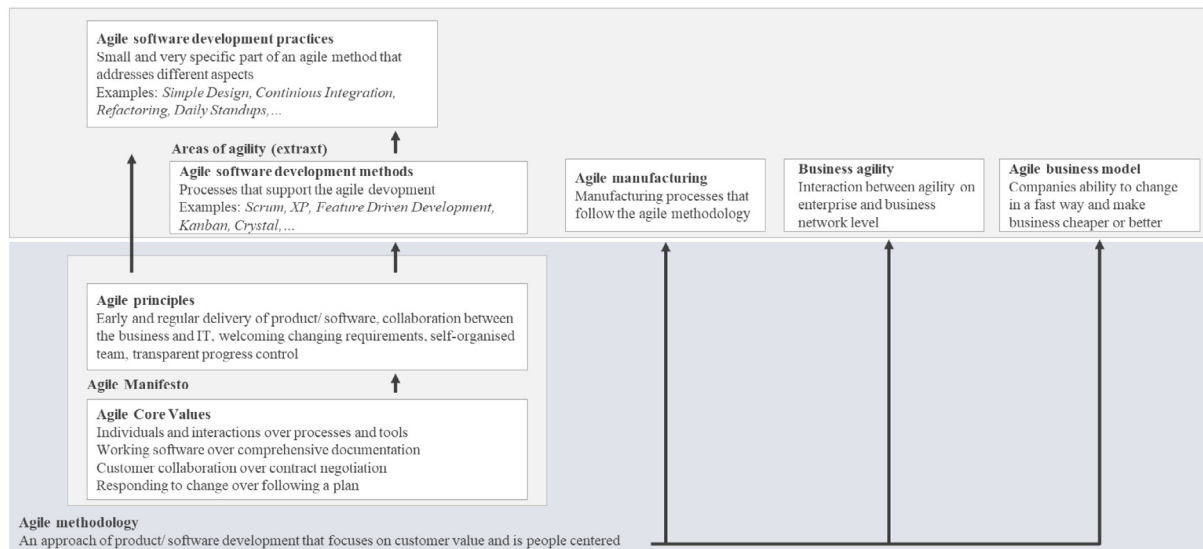


Fig. 1. Agile business competence areas and their relationship.

Source: Own representation based on Kettunen (2009), Diebold et al. (2016), Helaakoski et al. (2006), Daniels (2014) and van Oosterhout et al. (2005).

1997; Kruchten, 1998; Palmer and Felsing, 2002; Anderson, 2004; Schwaber, 2004).

The Agile Manifesto is comprised of four values and twelve principles with the goal of optimizing the software development process and collaboration with and within teams. Focusing on the development of customer value, many agile methods and practices that can also be applied in other non-IT related domains (Highsmith, 2010; Parente, 2015) have been developed as well (see Table 1). Practices are associated with one method, but can also be partially applied in combination with other methods.

The use of agile methods is particularly suitable for complex product development or project situations characterized by rapid and frequent changes (Kurtz and Snowden, 2003; Stacey and Mowles, 2015). Agile methods aim to reduce this complexity through accelerated reaction speed, improved collaboration (Kaim et al., 2019), and improved trust between team members but also with the customer. Additionally, simpler processes, reduced change costs and less time spent on changes result in increased productivity and a lower defect rate (Shah and Nies, 2008; Baig et al., 2017; Prater et al., 2001). This increases the quality of the product and reduces complexity (Anwer et al., 2017).

The most widely used agile methods are Scrum, Kanban, XP, Feature Driven Development and Crystal (VersionOne Collaboration, 2019). According to Schwaber and Sutherlands, the creators of Scrum, Scrum is a framework for people to address complex adaptive problems while delivering productively and creatively products of the highest possible value (Schwaber, 2004). Through the application of an iterative approach using sprints, daily synchronization meetings, like daily standups and continuous improvements using retrospectives, various improvements compared to the classical approach shall be achieved. The goal is to increase productivity, foster continuous feedback, reduce time to market of the product and embrace change (Ashraf and Aftab, 2017).

Kanban for software development aims to adopt the lean principles from manufacturing, such as the elimination of waste, amplification of learning and deciding as late as possible. Kanban uses visualization of the workflow, limitation of work in progress and continuous improvement to achieve a workflow (Ahmad et al., 2018; Anderson, 2010).

Its creator, Kent Beck, describes XP described as a “lightweight” method of software development that is based on simplicity, communication, courage, feedback and respect. It is a “process of experimentation and improvement” without a “given software process that can be pointed to as the one and only definition of Extreme Programming” (Beck, 2000). XP is a very technical method that uses practices such as refactoring, continuous integration of the software and test-driven development.

Feature Driven Development (FDD) is a “lightweight” and model-driven software development process. The goal is the frequent delivery of tangible work results. In FDD, a feature is defined as “a customer-evaluated functionality that can be implemented in two weeks or less” (Pang and Blair, 2004, p. 86). To achieve the frequent delivery of software or small pieces of a product, feature teams and inspections are used among other practices.

The Crystal method family comprises a number of different methods. Depending on the size and criticality of the project the most appropriate method should be chosen (Abrahamsson et al., 2002; Cockburn, 2005). However, certain rules, characteristics, and values are common to all methods in the Crystal family. These include the incremental approach, involvement of the user and the focus on human communication and collaboration.

The aim of this literature review is to focus on papers that describe the use of agile methods and practices in established logistics companies and start-ups.

3. Identification of the research gap

To validate the need of a systematic literature review related publications have been analyzed to verify the existence of a research gap.

3.1. Related work

This section describes other literature reviews and mapping studies that are related to this field of research. Before conducting the SLR, the research gap was verified by looking at other literature reviews and mapping studies. So far, only a few other literature reviews and mapping studies have been conducted related to research into logistics companies with regard to their

Table 1
Overview of the most common agile methods and associated agile practices (Beck, 2000; Palmer and Felsing, 2002; Schwaber, 2004; VersionOne CollabNet, 2019; Cockburn, 1998; Abrahamsson et al., 2003).

Agile method	Agile practices
Scrum	Sprint, Planning, Daily Standups, Retrospectives, Product Owner, Scrum Master, etc.
Kanban	Visualization, Limit Work in Progress, Feedback Cycles, etc.
XP	Refactoring, Continuous Integration, Test-driven Development, Pair Programming, etc.
FDD	Feature Teams, Inspections, Code Ownership, Regular Builds of the Software, etc.
Crystal	Frequent Delivery, Reflective Improvement, Close Communication, High user Involvement, etc.

use of agile methodologies. The next paragraphs summarize the most relevant reviews (see Fig. 2).

Perego, Perotti and Mangiaracina classified 44 studies on information and communication technology (ICT) for logistics and freight transportation. They found relatively few, but primarily recent studies. The authors discovered that ICT adoption in the logistics industry and the organization of IT, through agile project management for example, are still underrepresented in literature. The review showed that many of the studies examined are either conceptual papers or empirical studies—that is, mostly based on case studies, surveys, or interviews (Perego et al., 2011).

In 2012 Gligor and Holcomb published their SLR with the purpose of providing a conceptual framework that explains the relationships between the capabilities of logistics enterprises in terms of their ability to achieve manufacturing, organizational and supply chain agility. The authors found that the literature mainly focuses on manufacturing flexibility, supply chain speed, or lean manufacturing to explain supply chain agility, but logistics capabilities have not been taken into account to achieve a more holistic view. The study has practical relevance, however, because the level of supply chain agility in a supply chain influences the efficiency and effectiveness of the collective efforts (Holcomb and Gligor, 2012).

As many companies use only parts of agile methods, known as agile practices, Diebold and Dahlem conducted a mapping study to study the use of agile practices. They discovered how project types, domains, and processes influence the selection of agile practices. After analyzing 24 studies, the results show that some practices are used more often and that the process and the domain influence the selection of different practices. Additionally, the results support Ken Schwaber's theory that usually agile methods are not used "completely", but that rather certain, particular practices are adopted (Schwaber, 2004; Diebold and Dahlem, 2014).

In 2014, Daniels published his PhD study focusing on characteristics of the agile methodology and its contribution to the success of new ventures within an entrepreneurial orientation. A literature review on agile characteristics and strategic management has been conducted as basis for qualitative data collection from agile experts within IT functions, and also entrepreneurial professors. Daniels found that agile methodologies can go beyond software development and foster the sustainability and success of start-ups. Acceptance of uncertainty, consistent communication, collaborative teams, lean organization, and iterative development are especially helpful for start-ups (Daniels, 2014).

The main purpose of Wudhikarn et al.'s literature review is to address the limited adoption of comprehensive intellectual capital methods in logistics studies, underdevelopment of specific performance indicators and measures used, and the lack of appreciation of human capital as internal strength. The review is based on 111 studies. They found that most measures used are mainly related to the financial aspect, even though some consider specific components of intellectual capital, such as process efficiency and effectiveness (Wudhikarn et al., 2018).

3.2. Gap analysis

To sum up the overview of related work, it can be said that it covers only a few aspects on the use of agile methods and practices in established logistics companies and start-ups. The following shortcomings can be observed:

- Perego, Perotti and Mangiaracina focus on ICT, but not on agile methods or practices, even though they touch slightly on the topic of agile project management;
- Gligor and Holcomb focus on supply chain agility but do not take agile methods and practices into account;
- Diebold and Dahlem described which agile practices are used by companies, but they did not consider established logistics companies or logistics start-ups;
- Daniels worked on an adjustment of the agile manifesto for start-ups, but analyzed neither the use of agile methods and practices in logistics start-ups, nor in established logistics companies;
- Wudhikarn et al. focus on performance indicators in the logistics industry that are based on human capital and not on financial aspects, as was common in the past.

Before conducting a SLR, the related work has been gathered to verify the existence of a research gap. To this end, this SLR was conducted as the overview of related work showed that no SLR had so far been conducted focusing on the use of agile methods and practices in logistics companies and start-ups. The increasing number of research projects on logistics start-ups demonstrates the importance of further research (Holdorf et al., 2015). The growing number of cooperations of established IT consulting companies with IT-based (logistical) start-ups through e.g. digital hubs, such as the Digital Hub Logistics of Lufthansa Industry Solutions GmbH & Co. KG (Favorit-Media-Relations GmbH, 2018), also shows the interest in the new innovations and working methods of the logistics start-ups from the perspective of large companies and their customers.

4. Research method

Systematic literature reviews are defined as a way of gathering evidence and then enabling researchers to reach a common understanding in the field of research and its status (Wohlin, 2014). The aim is not only to conduct individual research studies, but also to build up knowledge by combining findings from different studies on the same topic. As one research gap was identified based on the collection of related work (see 3), this SLR is necessary to gather already existing research on the topic of traditional logistics companies and logistics start-ups and their use of agile methods and practices. It is intended to provide a framework for the subsequent research activities and to propose areas for further investigation (Brereton et al., 2007). To conduct the systematic literature review appropriate guidelines have been followed, specifically the guidelines by Kitchenham and Charters (Kitchenham and Charters, 2007). Based on these guidelines, this SLR is comprised of the following three main phases and associated stages:

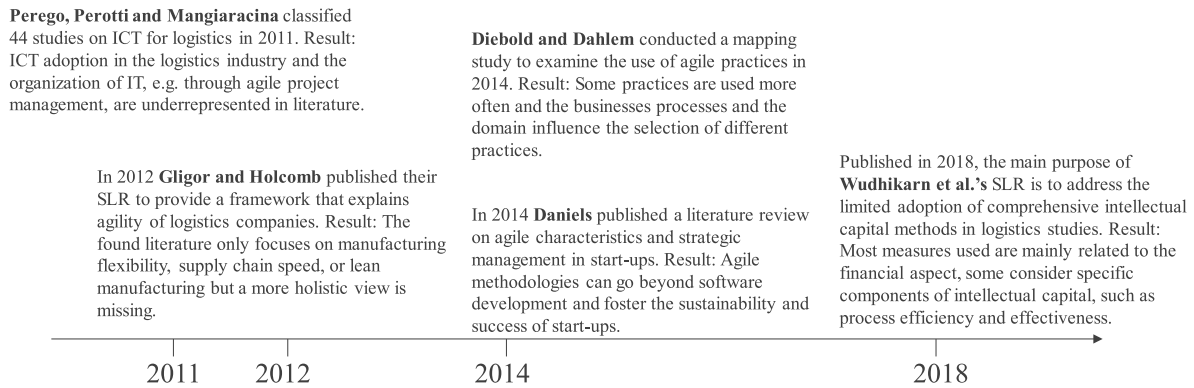


Fig. 2. Related work has not covered the use of agile methods and practices in logistics companies and logistics start-ups.

- Planning
 - Identify need of SLR
 - Specify RQs
 - Develop review protocol
 - Evaluate review protocol
- Conducting
 - Search
 - Study selection
 - Quality assessment
 - Data extraction
 - Data analysis
- Reporting
 - Extract and discuss results
 - Write report
 - Evaluate report

4.1. Objective and research questions

The goal of this SLR was to gather the current state of the literature related to agile methodologies at established logistics companies as well as logistics start-ups. Additionally, it is the goal to determine where the research fits into the current body of knowledge. Therefore, three complementary research questions (RQ) were created, as specified below:

Research Question 1: Which agile methods and practices do traditional logistics companies and logistics start-ups use?

This RQ is about finding out which agile methods and practices are actually used by traditional logistics companies and logistics start-ups in their IT departments. The goal is to compare whether traditional logistics companies and start-ups use similar agile methods and practices. Based on the results, it is possible to deduce, for example, which factors influence the selection of agile methods and practices and in which company context which agile methods and practices are used.

Research Question 2: Which challenges do traditional logistics companies and logistics start-ups solve with agile methods?

The goal of the second RQ is to find out why traditional logistics companies and logistics start-ups use agile methods and practices. It is analyzed which kind of problems logistics companies seek to solve using agile methods and practices as these methods promise to generate added value for the customer faster and more effectively. In addition, it is considered which improvements logistics companies hope to achieve by using agile

methods, since the methods also aim to streamline processes and improve the cooperation within the teams.

Research Question 3: What difficulties do traditional logistics companies and logistics start-ups face concerning the adoption of agile methods and practices?

This third RQ focuses on the difficulties traditional logistics companies as well as logistics start-ups encounter introducing and using agile methods and practices. These difficulties can be of different nature, e.g. difficulties during the agile transformation and with the understanding of agile methods in the IT teams or also with the customer, who expects a different approach of the IT teams. In addition, existing processes in logistics companies can prevent that agile methods are used in the best possible way and can thus not develop their full potential. Based on the results of this research question, it can be examined to what extent traditional logistics companies face other difficulties than logistics start-ups.

4.2. Development of a research protocol

The research protocol is a detailed plan that defines the procedure for SLR. It provides an overview of all underlying conditions and criteria applied in the selection of primary studies, quality measures, and etcetera. The research protocol underlying this SLR was designed based on the Kitchenham and Charters' Guidelines for SLR (Kitchenham and Charters, 2007). To ensure accountability the research protocol was defined by both authors. The research protocol describes the main aspects of the research procedure, including data sources, search strategy, study selection, quality assessment, data extraction and data analysis (Zielske and Held, 2019).

4.3. Search strategy

After the definition of the research objectives and the RQs, the research strategy was defined. Keywords were selected and combined into a search string. A search process was specified to reduce the number of papers found. To find keywords as criteria for the search, an iterative approach was taken. After the first definition of keywords, further keywords from relevant papers were extracted and alternative spellings and synonyms were subsequently identified. To optimize the search process, the keywords were refined after testing them in digital libraries and finding additional keywords in relevant papers. The final list can be found in Table 2. Using the keywords in plural made no significant difference.

The keywords were then connected with Boolean operators to design the search string as follows:

Search string : ST = [Agile] + [Logistics] + [Companies]

In more detail, the search string appears as follows:

Table 2
Search keywords used.

Topic	Subtopic	Search Keyword
Agile	Agile approach Agile methods	Agile Scrum, Kanban, Extreme programming, Lean startup
Logistics	Service Logistics service industry	Freight, Transport, Logistics service Third party logistics, Fourth party logistics, Logistics service provider, Supply chain
Companies	Traditional companies Start-ups	Company, Firm Startup, Start-up, Small medium enterprise, Venture

Table 3
Search space.

Digital library	Search strategy	Scope	Date of search
Science direct	Abstract, title and keywords	Sciences, economic and social science, and some arts and humanities titles	04 June 2019
Google scholar	Full text	As it is unclear which publishers are included in Google Scholar, it is used as a comprehensive addition to the other databases	06 June 2019
SpringerLink	Abstract and keywords	Sciences, economic and social science, and some arts and humanities titles	05 June 2019
IEEEExplore	Abstract and keywords	Electrical engineering and computer science	02 June 2019
ACM	Abstract and keywords	Computing and information technology	03 June 2019
Wiley	Abstract and keywords	Sciences, economic and social science, and some arts and humanities titles	03 June 2019
Emerald	Abstract and keywords	Business, management, real estate economics and finance	03 June 2019
JSTOR	Abstract, title and keywords	Academic journals in 75 disciplines including economics, engineering, management, technology, transportation	29 January 2020
EBSCO	Abstract, title and subject terms	Publications that focus on technology, natural sciences and economics from various publishing houses	06 February 2020

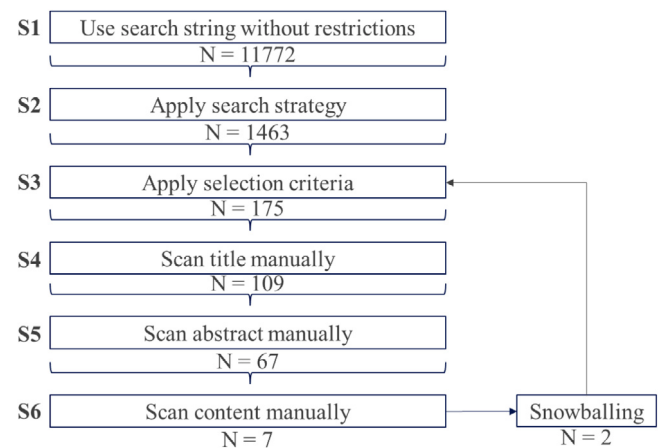
(agile OR scrum OR kanban OR “extreme programming” OR “lean startup”) AND (freight OR transport OR “logistics service provider” OR “fourth party logistics” OR “Third party logistics” OR “Logistics service” OR “supply chain”) AND (company OR firm OR startup OR start-up OR venture OR “small medium enterprise”)

Included in the search space were digital libraries and conference proceedings. They were selected based on their research scope. As every digital library has its own characteristics regarding its search engines, the search string was adjusted for every library. The details are documented in a separate document that includes the following information for each library (Zielske and Held, 2019) (see extract Table 3):

- name
- search strategy
- scope of the digital library
- date of search
- the adapted version of the search string

At the first stage, a large number of papers was found (11.772 findings). To reduce the results, the search was conducted in several stages, as shown in Fig. 3. Additionally, a reference search was used to find papers that cited the selected paper - a strategy referred to henceforth as “forward snowballing” - and papers that are in the reference list of the selected paper (backward snowballing) (Wohlin, 2014). Through snowballing, an additional 122 papers were found. 78 papers were found through forward snowballing, and 44 papers through backward snowballing. For these papers, the search process was started at stage 3. At the end of this second search process, two additional papers were identified that were taken into account for data extraction.

Comparing the results of this search, which is mainly based on the title, abstract and keywords of the publications, with the results of a full text search, a clear difference in the number of results becomes visible. Instead of the 11.772 papers found in this

**Fig. 3.** The search process comprises six steps and snowballing.

SLR in the first step S1 (see Fig. 3), a full-text search finds 72.062 papers. As this number of results can no longer be evaluated reasonably, this SLR was limited to title, abstract and keywords if possible.

4.4. Study selection

Studies are selected based on the search criteria described below, which are divided into inclusion and exclusion criteria. Inclusion and exclusion criteria aim to identify studies that provide direct evidence about the RQs. Three inclusion criteria were defined based on the RQs (see Inclusion criteria 4, 5 and 6 in Table 4). Since the aim of this work is to take up the international state of research, the focus was on English language papers (see Inclusion criteria 1 in Table 4). The time restriction on papers published after 1999 was made as the Agile Manifesto is from

Table 4
Inclusion and exclusion criteria.

#	Inclusion criteria	Exclusion criteria
1	Papers written in English	No full books, no master thesis
2	Papers published between 1999–2019	Papers with results that had been already published
3	Specific book chapter (published between 1999–2019)	Papers that were not focused on agile methodologies or whose focus moved away from agile methodologies
4	Papers presenting approaches to solve problems with agile methods in the logistics industry	
5	Papers presenting the use of agile methods in the logistics industry	
6	Papers associated with challenges of the application of agile methods in the logistics industry	

2001 (see Inclusion criteria 2 and 3 in Table 4). The agile methods, whose use is to be depicted in this research, are based on the idea of the Agile Manifesto and therefore were only developed from around this point in time. Furthermore, it is the goal of this work to reflect the current state of research and not the development over time. Books and master theses were excluded (see Exclusion criteria 1 in Table 4). The aim is to find dedicated articles or papers on the topic, which also have a good research quality and were peer-reviewed. Duplicates are considered only once (see Exclusion criteria 2 in Table 4). The last exclusion criterion ensures the research relevance to the RQs of this study (see Exclusion criteria 3 in Table 4).

These criteria were applied as follows to step three (see S3–Apply selection criteria, Fig. 3) of the search process (see Table 4):

1. The first three inclusion criteria have to be fulfilled
2. The selection criteria 4–6 are used as guideline for whether or not studies should be selected
3. Studies should be excluded if any exclusion criteria can be applied

At the end of the data extraction only seven papers were found that were relevant to our study and two were found through snowballing. In total, nine papers were discovered and it was verified that they contained relevant information. If a paper contained relevant information, it was included in this study. Through the snowballing process, a few authors who published more than one relevant publication were also found.

In order to evaluate how many German-speaking papers were excluded due to the restriction to English-speaking papers, the search was carried out on a trial basis in a digital library that also contains German language papers. 95 publications were found for step 1 (S1) (see Fig. 3). The continuation of the SLR e.g. in German-speaking publications or other languages would be a possibility for further research in the future.

4.5. Quality assessment

To assist data analysis, quality assessment criteria are used to evaluate the quality of the studies that passed the inclusion and exclusion criteria. The quality is evaluated based on the criteria elaborated in Table 5 (Schön et al., 2017), for which a three-point Likert scale is used. The assessment criteria are based on the guidelines from Kitchenham and Charters and suggestions from Fink (Kitchenham and Charters, 2007; Fink, 2013). The list of suggested evaluation parameters was reviewed and appropriate questions were selected. A measurement scale was constructed since a Yes/No answer would have been misleading. Each of the five quality criteria was applied to evaluate the selected papers. Papers lacking a detailed description of the research process (QA2) or a description of the research objective (QA5) were not further included in the data analysis. Papers that did not validate

their research idea (QA1), did include a personal opinion (QA3) or were cited only rarely (QA4) were examined to determine why this was the case and included if the research quality was not affected (see Appendix A).

4.6. Data extraction

Based on Kitchenham and Charters' guidelines (Kitchenham and Charters, 2007), an Excel spreadsheet was set up for data extraction. In this extraction form, the following quantitative and qualitative parameters were used (see Table 6).

During the data extraction process, it became clear that it was not always possible to excerpt data for all parameters because the studies were reported differently. Missing parameters were marked with "n/a" in order to complete the form anyway. Quantitative data was extracted, such as the publication channel and date, as was qualitative data, such as content and summaries.

5. Results

Nine relevant studies were ultimately included in this SLR. First, characteristics of the studies and quantitative data (e.g., publication channel, research method or quality overall) will be summarized. Findings related to the RQs will then be presented.

5.1. Summary of studies

The nine relevant papers were published in conference proceedings, scientific journals, book chapters, or as doctoral studies. Two articles were published in conference proceedings, five were published in scientific journals; there was one book chapter and one PhD study included.

In summary, three papers used case studies, one study was a single case study and two papers were a multiple case study comparing results from different case studies. Four publications presented a framework that was developed by the authors without further research to validate their approaches. Two papers presented the results of a survey that was conducted.

Overall, it can be stated that the use of agile methods and practices in logistics companies and start-ups has been investigated in real-life contexts in close proximity to existing work practices in companies and start-ups. It needs to be noted that a single case study may not be generalized to apply in other contexts, which could have an impact on the interpretation of the results.

A three-point Likert scale was used to assess the quality of the identified papers (see Table 5). The overall results are shown in Fig. 4. The first parameter inspected whether the scientific idea is validated through further research. Five papers validated the approach used by those carrying out the case studies either through (multiple) case studies or through surveys. In the four remaining proposals found, the researchers developed a theoretical framework. QA2 examined whether the approach was described

Table 5
Quality assessment criteria.

Item	Assessment criteria	Score	Description
QA1	Is the scientific idea validated?	−1	No, it is not validated
		0	Partially; it is validated in a laboratory or only parts of the proposal are validated
		+1	Yes, by a case study/survey/etc.
QA2	Does the publication present a detailed description of the approach?	−1	No, details are missing
		0	Partially; if you want to use the approach, you need to read the references
		+1	Yes, the approach can be used with presented details
QA3	Does the publication include a personal opinion piece or viewpoint?	−1	Yes, it does.
		0	Partially; since related work is explained and paper is set into a specific context
		+1	No, the paper is based on research
QA4	Has the publication been cited by other authors?	−1	No, no one cited the study
		0	Partially; between 1–5 articles cited the study
		+1	Yes, more than 5 articles cited the study
QA5	Has the publication a clear statement of the objective of the study?	−1	No, aims are not described
		0	Partially; aims are described but unclearly
		+1	Yes, aims are well described and clear

Table 6
Overview on data extracted and need of the data to conduct the SLR.

Parameters	Data type	Benefit of data for the SLR
General information	Title, Authors, Publication date, DOI	Gathering of general information for recognition of the publication
Publication data	Journal/ conference, (Conference date) Publisher, Volume, Issue, Pages, Keywords, Abstract	Classification of the paper e.g. regarding age and quality
Research type	Research method (Development of a framework, Case study, Survey, Systematic literature review, other)	Understanding of the origin of the research data
Agile method	e.g. Scrum, XP, Kanban, Agile Manufacturing	Data used to answer RQ 1
Type of company	Established, Start-up	Comprehension of the context analyzed
Company size	(Number of employees)	
Type of logistics	Supply chain, Internal logistics, Freight, Inventory management, Logistics service provider, Urban logistics	
Company assets	Asset-based, Asset-light	
Problems within companies	e.g., 'Change, uncertainty and unpredictability within business environment and necessity of appropriate responses to changes'	Data analyzed to answer RQ2
Aims of optimization	e.g., 'Cope with the high levels of uncertainty', 'Increase efficiency and effectiveness through communication'	
Challenges with agile methods	e.g. 'Longer gestation periods with higher technical risk', 'Difficulty to gather customer feedback'	Data analyzed to answer RQ3
Quality assessment criteria	Idea validation, Detailed approach, Personal opinion, Cited by others, Clear objective, Number of papers that cited the study	Dated collected to assess the publications' quality based on the SLR guideline
Personal assessment	Comments, Selection status (included/excluded)	Remark by authors on the publication

in detail. In three papers, the approach is described in detail so that other researcher could use it, and in six papers the approach is only partially described, which means that anyone who intends to use the approach must read the references. No paper missing a detailed approach was included. QA3 queried whether the study provided a personal opinion or viewpoint: five of the nine papers are based only on research, and the other four studies included parts of personal viewpoints, because related work is explained and the papers are set into a specific context. QA4 explores whether the study has been cited by other authors. To assess this, Google Scholar was used to determine the number of times the study was cited (assessment date 11.02.2020). Seven papers have been cited more than five times; two paper have been cited fewer than five times. QA5 tested whether the publication clearly states the objective of the study. Eight studies have a clear objective. One study has an objective that is described only vaguely. None of the papers lacked the description of an objective.

In summary, one paper fulfilled all of the described criteria and was cited more than five times (Pijpers et al., 2012). The results may differ at the publication date of this SLR because the actual number of citations could change.

5.2. Research question 1: Which agile methods and practices do traditional logistics companies and logistics start-ups use?

Of the nine relevant studies, all focused on established logistics companies (van Oosterhout et al., 2005; Yusuf et al., 1999; Pijpers et al., 2012; Wang, 2011; Morlok and Chang, 2004; Marlow and Paixão Casaca, 2003; Tuan and Thang, 2013; Dybå and Dingsøyr, 2015). No publication that focused on logistics start-ups and agility, and/ or agile methods, and/ or agile practices was found. Therefore, no publication focusing on logistics start-ups could be included. Even though all studies included focused on agility, only some named concrete agile methods from agile software development. Five papers concentrate on other areas of agility that are applied within established logistics companies (see Table 7).

The nine relevant studies show that some established logistics companies use agile methods like XP and Scrum but also other areas of agility such as business agility, agile business model, or agile supply chain.

The aim of the first RQ was to analyze the agile practices used in established logistics companies and logistics start-ups. For established logistics companies, no study was found that described the use of agile practices. The papers describe only

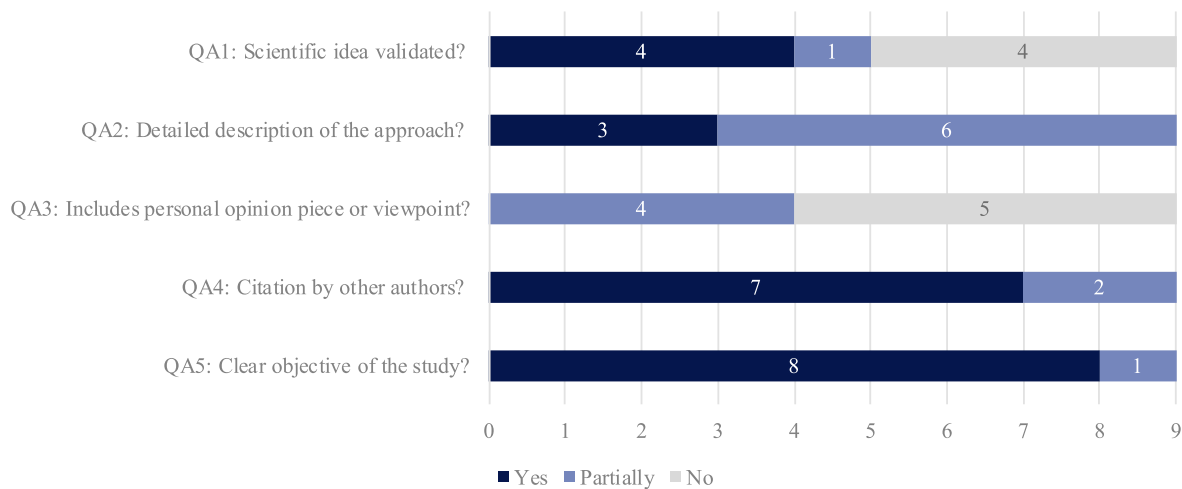


Fig. 4. Results of the quality assessment.

Table 7

Agile methods or areas applied within logistics companies and start-ups.

Agile method/ area	Number of agile methods/ areas mentioned in studies
eXtreme Programming (Method ASD)	1
Scrum (Method ASD)	2
Business agility	1
Agile supply chain	2
Agile manufacturing	2
Agile organization	1

Table 8

Applied agile practices.

Agile guidelines	Number of papers that covered agile guidelines
Regular communication between business and IT	2
Empowerment of the team	1
Flat hierarchies	2
Focus on knowledge of the people not technologies	1
Customer focus	2
Continuous improvement	1

guidelines that are helpful for an agile organization, but would also be used in a setting with classical project management, e.g., a waterfall organization (McAvoy and Butler, 2009). For logistics start-ups no relevant studies have been found (see Table 8).

Only three of the nine relevant studies detailed the use of agile methods by describing the use of agile guidelines and no included paper described the use of agile practices.

Upon closer inspection it becomes clear that the studies have somewhat differing understandings of agility. This corresponds to the statement that agility, as already described, is a multifaceted concept. Some studies focus on agile methods based on ASD such as Scrum and XP while others focus on different areas of agility such as agile supply chains, agile business models, and business agility. The studies included focusing on ASD methods do not define the agile methods like Scrum and XP, but only name them. The definitions of the other areas partially overlap, but are not completely consistent. Wang describes that the “agile supply chain [...] is regarded as the interchangeable terms of responsive supply chain”. (Wang, 2011). For supply chain agility, only one definition was found.

Looking at the definition of agile manufacturing, Wang and Yusuf, Sarhadi and Gunasekaran agree that agile manufacturing is based on responsiveness to social and environmental issues, the mobilization of core competencies, and the focus on “products and services with high information and value-adding content” (Yusuf et al., 1999; Wang, 2011). Wang adds “rapid prototyping, concurrent engineering, multi-skilled and flexible

people, continuous improvement, team working, change and risk management, information technology and empowering”, and Yusuf, Sarhadi and Gunasekaran add “synthesis of diverse technologies” and “intra-enterprise and inter-enterprise integration”. For business agility, only one definition was found in the nine studies, so no comparison was possible. Business agility was defined as “being able to swiftly and easily change businesses and business processes outside the normal level of flexibility to effectively deal with highly unpredictable external and internal changes” (van Oosterhout et al., 2005).

5.3. Research question 2: Which challenges do traditional logistics companies and logistics start-ups solve with agile methods?

The challenges examined by this SLR that established logistics companies aim to solve with agile methods and practices are clustered into the following groups based on the experiences from the studies included:

- Customer-related challenges
- Product-related challenges
- Communication-related challenges
- Processual and organizational challenges

The challenges that logistics start-ups want to solve with agile methods and practices are not taken into account as no paper that focuses on logistics start-ups and agile methods and/ or practices has been found.

Table 9

Challenges that established logistics companies want to solve with agile methods, practices, or areas.

Cluster	Challenge	Used agile method or practice/ area to face challenges	Company characteristics (number of employees)	Papers
Customer	Difficulty satisfying customer requirements within the agreed-upon timeframe with high quality service levels	Business agility, Agile manufacturing,	Established (n/a; > 50 employees)	van Oosterhout et al. (2005), Wang (2011), Gurahoo and Salisbury (2018)
	Adaption to changing requirements takes too long	Business agility	Established (n/a)	van Oosterhout et al. (2005)
Product	Need for lower-priced products	Business agility	Established (n/a)	van Oosterhout et al. (2005)
Communication	Alignment of IT and business	Agile business model	Established (SME; large enterprises)	Pijpers et al. (2012)
Processual and organizational	Personnel bottlenecks, time pressure, and lack of resources	Business agility, agile supply chain	Established (n/a)	van Oosterhout et al. (2005), Morlok and Chang (2004), Marlow and Paixão Casaca (2003)

For each group the challenges are stated together with the applied agile method or practice (see Table 9). Additionally, how many employees work in the established logistics company is specified, if mentioned in the publication.

Established logistics companies want to solve customer-related and other challenges through the use of agile methods and practices. The want to improve their ability to satisfy changing customer requirements and learn from customer feedback, and they want to be able to do it more quickly. Logistics companies have a need for lower-priced products that they want to acquire through the use of business agility. Through the application of an agile business model, established companies want to improve the alignment between IT and business and reduce their documentation to a minimal, strictly necessary amount. Looking at the processual and organizational challenges, logistics companies face challenges related to personnel bottlenecks, general lack of resources, and intensive time pressure. Business agility and agile supply chain are used to reduce these. To reduce the number of complex processes that hinder productivity and increase the number of errors made, continuous delivery, a type of software engineering approach, is used in established logistics companies (see Table 9).

5.4. Research question 3: What difficulties do traditional logistics companies and logistics start-ups face?

The difficulties that established logistics companies face when applying agile methods and practices found in this SLR are clustered into the following groups based on the experiences from the studies included:

- Product-related difficulties
- Processual difficulties
- People-related difficulties

For each group the difficulties are stated together with the applied agile method or practice. In addition, it is specified how many employees work in the established logistics company, if stated in the study (see Table 10).

The challenges that logistics start-ups face applying agile methods and practices are not taken into account as no paper that focuses on logistics start-ups and agile methods and/or practices has been found.

It needs to be noted that, even though many papers describe why logistics companies want to apply agile methods and practices and what challenges they plan to address, only three out of nine studies describe the difficulties established companies actually face.

Even while applying agile methods and practices, established logistics companies have difficulties designing a product that is receptive to changing requirements and allows agility. Often their traditional products have problems dealing with short-term changes. Looking at the processes of established logistics companies it is difficult to identify the drivers that enable a shift towards agility. Established logistics companies face additional problems regarding the mindset and culture within the company when using agile methods and practices as well, because agile methodologies mean a huge cultural shift towards collaboration within teams and with customers that may not have been traditionally present.

6. Discussion

In sum, nine relevant studies have been found and analyzed according to our research protocol. The findings of the SLR will be discussed. First, the findings related to our RQs will be described. Secondly the limitations of this study will be identified.

6.1. Meaning of the findings

In this section, the findings of the SLR will be discussed in general, and as they relate to the RQs.

6.1.1. General findings

The results of the SLR show that the use of agile methods and practices, and other agile areas such as supply chain agility, as related to and implemented by established logistics companies, have been studied. No study has been found for logistics start-ups. As the included studies focus specifically on agile areas such as business agility, agile business model, and agile supply chain, this SLR could create the impression that established logistics companies are pioneers in the agile community. The opposite is the case. For the agile areas mentioned in the included studies like business agility, the definitions differ from the definitions that are rather new within the agile community. The included study from Oosterhout is from 2005, and the studies that focus on business agility as it is defined today are from 2015 (van Oosterhout et al., 2005; Narayan, 2015). In fact, the established logistics companies examined here have not yet made significant advancements with the agile transformation. The studies show that comparatively few agile methods and practices are used within these firms. Furthermore, it needs to be noted that established logistics companies do not see themselves as IT companies. That might be a reason for their rather late adaption of agile methods. In summary, it can be concluded that the use of agile methods and practices in established logistics companies is an important

Table 10
Difficulties established logistics companies face with the use of agile methods/practices/areas.

Cluster	Difficulties	Applied agile method/ practice	Company characteristics (employees)	Paper
Product	Find the right design of a product that allows supply chain agility	Agile manufacturing	Established (> 50 employees)	Wang (2011)
Processual	Identify drivers that increase supply chain agility	Supply chain agility	Established (n/a)	Yusuf et al. (1999)
People	Mindset, culture	Business agility	Established (n/a)	van Oosterhout et al. (2005)

research topic and that there is a special research gap with regard to examining the use of agile methods and practices in logistics start-ups. In addition, the heterogeneity of the studied aspects in the relevant studies demonstrates that this is a complex research field with various influences from other fields that can and should be taken into account. Furthermore, this research field is closely related to existing work practices as most of the included studies base their research on real-life data.

6.1.2. Findings research question 1

Concerning the first RQ, in sum, XP, Scrum, and other agile areas such as agile manufacturing and business agility are used by established logistics firms. No response can be given for logistics start-ups as no paper was available that focused on the use of agile methods and practices in start-ups. In terms of agile practices, established logistics companies mostly use guidelines such as continuous improvement, team empowerment, and customer focus. It needs to be noted that these guidelines are helpful to build a successful agile organization but are not agile practices in a proper sense. In light of the missing studies on logistics start-ups, further research with regard to logistics start-ups and the use of agile methods and practices is required.

6.1.3. Findings research question 2

Challenges that established logistics companies aim to solve with agile methods and practices are clustered into customer-related challenges, product-related challenges, communication-related challenges, and processual and organizational challenges. As no study that focused on logistics start-ups was included, no specific challenges for logistics start-ups could be identified. Most of the challenges established logistics companies pertain to customers. Through the use of agile methods and practices, established logistics companies want to increase their ability to satisfy changing customer requirements and reduce costs of products, as well as their speed in doing so. Another goal is to align business and IT through communication, and to reduce personnel bottlenecks and to deal with complex processes. To this end, it can be concluded that agile methods and practices could be helpful in solving these problems.

6.1.4. Findings research question 3

The third RQ discussed difficulties that established logistics companies face when applying agile methods and practices and clustered the difficulties into product-related, processual, and people-related difficulties. Challenges when applying agile methods and practices are to find the right product design that allows for supply chain agility, to identify drivers that increase agility, and most demanding of all, creating an agile culture and introducing an agile mindset. Even though this is but one of many people-related difficulties, it should not be underestimated, as the success of agile methods and practices depends strongly upon the support and comprehension of employees.

6.2. Limitations of the systematic literature review

Due to the large quantity of published literature, there may be some papers that were missed even though a predefined research protocol was used and followed to ensure the completeness of this study and reduce the threat of systematic errors. Additionally, the completeness strongly depends on selected keywords and limitations of the digital libraries. For the definition of the keywords an iterative approach was chosen to develop an extensive list of keywords. Keywords applied in related SLRs were used initially and enhanced if the keyword list was not able to find state-of-the-art publications in the research field of this SLR. Multiple search engines with different focuses were used to reduce their limitations. Moreover, the risk of incompleteness was addressed through forward and backward snowballing, which also reduces the risk of bias in the selection process. Both authors decided individually in steps four to six (scan title, abstract and content manually) which papers were relevant and should be included and consolidated their findings afterwards. Performing these selection steps might have caused a certain degree of subjectivity. The chosen selection criteria might be another weakness of this SLR because, for example, only papers written in English language were included, meaning that other possibly relevant studies written in other languages were excluded ([Göpfert and Seeßle, 2019](#); [Sucky and Asdecker, 2019](#); [Fottner and Hietschold, 2018](#); [Schwemmer, 2019](#); [Wegner, 2019](#)).

The results of this SLR indicate that, so far, only a few publications cover established logistics companies' and start-ups' use of agile methods and practices. Agile methods are not always applied as described in theory, which limits analysis, as the data from different publications is difficult to compare. To overcome this, definitions of agile methods and practices were compared as well (see chapter 4.2).

Finally, no paper that covered the use of agile methods and practices in logistics start-ups was found.

7. Conclusions and future work

This paper presents an SLR on the use of agile methods and practices by established logistics companies and logistics start-ups. The aim of the SLR has been to capture the current state of the publications related to the integrated fields of traditional logistics companies, logistics start-ups and agility. This review is based on the guidelines provided by Kitchenham and Charters ([Kitchenham and Charters, 2007](#)). We identified 11,772 papers in the initial search without restrictions, and 112 through the snowballing technique. To reduce the number of findings, the search process was carried out in different steps. In total, only nine studies were identified as relevant and analyzed in subsequent steps. In the first phase, a quality assessment was performed to evaluate the quality of each publication. The publications were then classified quantitatively according to research method, publication date, and channel. All papers included were published after 1999.

Table 11

Overview quality assessment of identified relevant papers.

Title	Authors	QA1	QA2	QA3	QA4	QA5
Measuring capacity flexibility of a transportation system	Edward K. Morlok, David J. Chang	No	Partly	Partly	More than 5	Partly
Combining maturity with agility: lessons learnt from a case study	Nguyen Ngoc Tuan, Huynh Quyet Thang	Yes	Partly	Partly	More than 5	Yes
Measuring lean ports performance	Peter B Marlow, Ana C Paixão Casaca	No	Partly	No	More than 5	Yes
Agile project management: from self-managing teams to large-scale development	Tore Dybå, Torgeir Dingsøy	No	Partly	Partly	More than 5	Yes
Using conceptual models to explore business-ICT alignment in networked value constellations	V. Pijpers, P. de Leenheer, J. Gordijn, H. Akkermans	Yes	Yes	No	More than 5	Yes
Assessing Business Agility: A Multi-Industry Study in The Netherlands in Business Agility and Information Technology Diffusion	van Oosterhout M., Waarts, E., van Hillegersberg, J.	Partly	Yes	No	More than 5	Yes
A Taxonomical Study of Agility Strategies and Supporting Supply Chain Management Practices	Wang, R.	Yes	Yes	No	1–5	Yes
Agile manufacturing: the drivers, concepts and attributes	Yusuf, Y.Y., Sarhadi, M., Gunasekaran, A.	No	Partly	Partly	More than 5	Yes
Lean and agile in small- and medium-sized enterprises: Complementary or incompatible?	Gurahoo, N Salisbury, R.	Yes	Partly	No	1–5	Yes

Another aim of this SLR was to determine where the research fits into the current body of knowledge of researchers and practitioners. Based on a qualitative analysis of the included studies, it can be concluded that a shared understanding of the use of agile methods and practices is not very well established neither in the logistics industry nor in research. Through a deeper analysis of the relevant studies it became clear that only a limited number of papers investigated the use of agile methods and practices in the logistics industry, and within established logistics companies. No paper that could be found investigated the use of agile methods and practices in logistics start-ups. For established logistics companies, the studies showed that only a few agile methods and practices are used. The concept of agility in established logistics companies is supported by the application of other agile areas and guidelines. We identified two agile methods – XP and Scrum – that are applied by some established logistics companies. Additionally, a range of other agile areas (business agility, supply chain agility, etc.) and guidelines (alignment of business and IT, empowerment of teams, etc.) that are used to support the concept of agility were also identified. Several challenges that can be solved with agile methods and practices have been found, as well as difficulties that can arise when using agile methods and practices.

Industrial practitioners can utilize these findings as guidelines to learn from the experiences of other logistics companies in regard to the use of agile methods and practices.

To summarize, it needs to be noted that the review shows the need for more empirical studies that work on the use of agile methods and practices covering logistics companies and especially logistics start-ups. In addition, it can be concluded that there is heterogeneity among logistics companies regarding the use of agile methods and practices. There are publications that focus on the use of agile methods and practices in established logistics companies, but there are no publications for logistics

start-ups. As an interesting next steps e.g. German and Chinese studies could be included as they are countries with a large logistics industry. Also, future research may deal with logistics start-ups specifically and could involve qualitative data collection based on interviews with logistics companies and start-ups. To this end, we aim to create a metamodel that describes the use of agile methods and practices by established logistics companies and logistics start-ups at a higher level.

CRedit authorship contribution statement

Malena Zielske: Conceptualization, Validation, Investigation, Writing – original draft, Writing – review & editing, Visualization.
Tobias Held: Validation, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

See Table 11.

Appendix B. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.jss.2022.111328>.

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