Big Data in Logistics – Identifying Potentials through Literature, Case Study and Expert Interview Analyses

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Abstract: In this contribution, we elaborate the current state of research and practice of Big Data in the field of logistics by means of a systematic literature review, a case study analysis and expert interviews. Although all interviewees are from Germany, viable perspectives and opinions of practitioners from worldwide operating companies were gained. Based on the analyzed information and the identified knowledge gaps, we developed implications for practice and for research. We call for an advanced interdisciplinary research, which integrate practitioners as early as possible. Practitioners should identify how Big Data can improve management decision or daily business. Management support was identified as essential in Big Data projects, besides department staff should be integrated and a holistic approach should be followed. Therefore, appropriate training for project members or hiring of new staff is needed. Thus, this paper offers fundamental new insights in the field of Big Data useful for practitioners and researchers.

1 Introduction and Motivation

The topic Big Data can be seen as a recent trend in the field of Information Systems (IS), equally significant for practitioners and academics [CCS12]. A survey of 100 senior executives of Fortune 1,000 companies revealed that more than 70% of the participants want to improve the "time to answer" through Big Data [Fer13]. In scientific literature, [CCS12] have identified a continuing trend in the past decade (2000-2011). In 2000, there were no publications on Big Data, in 2011, there were already 95. The amount of data to be stored is getting bigger, also due to data creation through the web, mobile devices and sensors [CCS12, Gob13]. Irrespective of the industry sector, the increasing data volume allows companies advantageous insights in their businesses [CCS12, Sch13]. The data acquisition is no problem anymore; the issue is rather to make the best possible use of the data for operational and strategic business [Gob13].

[CCS12] conducted a literature review of 3,602 articles as of 2000 in the area of Business Intelligence & Analytics (BI&A) and Big Data. One of the identified Top

Keywords was “supply chain”, the subject of logistics, however, did not emerge. A lot of data rises from sensors, telematics, GPS, etc., (techniques used in the logistics industry) which is why we consider the fields of freight transport and inventory management to have a high potential. This hypothesis is also supported by [SK13], who inter alia identify two Big Data topics with a high impact on logistics in a period of less than five years (The analysis of data in real-time to provide value-adding information to the costumer and the analysis of previously unused data sources).

This information leads us to the following research questions (RQ):

RQ1: What is the current scientific status quo of the topic Big Data in logistics?
RQ2: Which use cases of Big Data are already implemented in the area of logistics?
RQ3: Is there any potential for the use of Big Data in new logistics scenarios?

To answer RQ1, we performed a literature review, while RQ2 was investigated through a case study analysis. To examine RQ3 we carried out four expert interviews. The paper is structured as follows. In the following section, we present our research methods. Afterwards, we briefly describe the results of the literature review, the case study analysis and the expert interviews. Then, we combine and discuss the results. Finally, we make recommendations and implications for research and practice.

2 Research Methods and Review Scope

2.1 Systematic Literature Review and Analyzed Articles

Since it is recognized as key instrument for the efficient analysis of large numbers of different sources [WW02], we used the systematic literature review as research method, thereby following the steps established by [WW02] and [Dib04].

First, we defined the review scope. We used the EBSCO literature database (including EconLit) to cover peer-reviewed business journals as well as industry/trade magazines. To get a broader base of literature, we also performed a google scholar search. Furthermore, in order to consider high quality papers, we searched for all A-ranked journals (not covered by EBSCO) in the VHB jourqual logistics ranking.

The research topic has already partially been described in the Motivation section, which led to the use of the keywords “logistics”, “transport” and “warehouse” in combination with “Big Data”.

In EBSCO, we used the phrase <"Big Data" AND (Logistic* OR Transport* OR Warehouse*)> and searched in title, subject terms and abstract. This resulted in 44 articles, of which only five were published in academic journals. In google scholar, we used the phrase <allintitle: Logistics OR Transport OR Warehouse "Big Data">, which yielded only six articles[1]. Two VHB A-ranked journals were not covered by EBSCO. By using the term <Big Data> we identified another three articles in these journals. For all identified academic papers we additionally performed a forward and backward search, which led to another 10 articles. We checked all papers for relevance by reading the abstract and thus received 28 relevant contributions.

None of the identified papers contains a systematic literature review of Big Data in the area of logistics. No related work could be identified. Thus, to the best of our knowledge, our contribution is the first to provide such insights.

According to the phases of [Dib04], the literature analysis and conclusion will be performed in the following sections.

2.2 Case Study Research

In addition, we aimed at capturing the status quo from practitioners. Therefore, we performed a case study research; a method used to examine phenomena in their natural context [My09].
We used Google for a broad, open search, applied the search term <"Big Data" "logistics" "case study"> and thus obtained more than 119,000 results. We successively went through the results and yielded 36 case studies on Big Data and logistics from the first 70 results. As the hit ratio then decreased significantly (we did not identify one relevant case study in the results 71 to 100) we terminated our search.
Overall, we identified 36 case studies and checked these for relevance. Case studies that only offered technical descriptions with no connection to business processes have not been considered further. We also excluded extremely superficial case studies that were rather promotion. The finally selected 14 case studies are listed in table 3.

2.3 Expert Interview

To get an overview of the potential use of Big Data in the area of logistics, we accomplished expert interviews, which are the most important technique for qualitative research [My09]. We applied the recommendations for construction, justification, ethical issues and tensions for interpretive research by [Wal06] and the principles of [My09] to apply a well-established research method.
We invited more than 150 German companies, which either come from the logistics industry or provide Big Data solutions, to participate in the interview. The return rate was below 16 % and most of the answers were refusals (due to a lack of time/resources or knowledge or because of corporate policies).
Lastly, five interviewees from three companies have been interviewed in four semi-structured expert interviews (cf. table 1).

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[1] We limited the search to title, as we only want to identify paper with high relevance to the topic. As google scholar provides access to a huge database, which contains also grey literature, we have to focus on the high relevant one paper. An open google scholar search reveals over 11,000 papers.

#	Interviewee position	Company's activity	Employees	Area of operation
1	Director of eFullfilment	Stationary trade logistics	~ 5,000	> 40 countries
2	Project Manager for Information Management	International contract logistics	> 11,000	18 countries
3	**3.1:** Head of IS Governance & Compliance	Logistics services and freight transport	~ 11,000	> 50 countries
	3.2: Member team Information Management			
4	Global Lead of Business Productions Solutions			

Table 1: Overview of Interviewees

The interview guide consists of open questions and supplemental questions to discuss interesting topics in detail. First some organizational topics were explained and an introduction (especially the sentence „Big Data") was given, to achieve a common understanding) was given. Afterwards the interviewee was asked how Big Data is used in his firm (which data is analyzed, where does the data rise and which data is persisted, where is a Big Data analysis useful and how does Big Data develop in the next 3-56 years). Then a case study (use of telematics to reduce downtime in freight transport) was presented and the interviewee was asked to evaluate and discuss this case study. Before saying goodbye, there was open space to discuss unasked questions. The guide was sent to the experts at least one day before the interview to enable sufficient preparation. The interviews, which took place in the timeframe from 2013-08-01 to 2013-11-29, were recorded and transcribed.

3 Analysis of Results

3.1 Literature Review Results

To start with, we clustered the reviewed papers in different categories. As we did not limit our search to one special field of logistics, different topics are discussed (cf. table 2).

Topic	Paper handle topic
Supply Chain	[Big13], [WF13b], [WF13a], [Wil13], [Bie13], [Lu13], [Sav12], [Bru12], [Cec12], [MGI11], [Cha13], [Lap13]
Transportation (public and freight)	[Mil13], [Bie13], [Cob13], [Sco14], [Bur13], [MGI11], [McC13], [Ali12], [Dai12], [Cow13]
Sales	[Gro14], [Rit14], [Hol14], [Sav12], [Bru12]
Manufacturing/Production	[LK12], [Gro14], [Byr12], [MGI11]
Inventory Management / Warehousing	[Tre13], [MGI11]
not specified	[Ola13], [CCS12]
Procurement	[Gro14]

Table 2: Overview of Big Data logistics topics

The most frequent topic is Supply Chain (SC), which is treated in one third of the papers. The second major topic is Transportation (freight and public transport).
As the data volume increases with the number of parties involved, it is not surprising that Big Data plays a major role in SC. As already mentioned, also the transportation industry has, due to the huge amount of data that can be generated (e.g., through sensors, GPS, mobile devices), great concerns about Big Data. Surprisingly, the Inventory Management (or Warehousing) industry is mentioned in two papers only, despite technologies (like Barcode and RFID) that may generate large data volumes. However, Big Data research is currently under-represented in this industry.

The papers on SC differ substantially. Some papers only explain to some degree why Big Data is important for Supply Chain Management (SCM) [HTZ13] or give recommendations how to start Big Data [Big13]. Other papers explain the connection of Big Data and predictive analysis [WF13a] and clarify how Big Data can be used to ameliorate the quality of predictions [WF13b]. [Wil13] identifies an obstacle that ought to be overcome; he explains that currently most information is collected and analyzed in the individual departments, data aggregation and a more holistic analysis is often missing. Therefore, it is important to distinguish relevant from unimportant data [Lap13]. To make good predictions it is necessary to get customer as well as consumer data [Bru12]. Although there are new possibilities to gather such information, the related risks must not be neglected. For instance, in case of an internationally deployed SC possibly deviating or stricter laws of other countries must be known and adhered to [Wil13].
Among the articles on transportation, there are also some papers with basic information, which motivate companies to adopt Big Data [Sco14]. Others describe existing software solutions like SAS[2] and how these can be applied in the transportation sector [Bie13]. Furthermore, there are studies describing the topic's future development. A survey reveals that 30% of the shippers and 27% of the third party logistics (3PL) providers state that they were planning on adopting a Big Data initiative [Bur13]. However, 50% of the shippers and 3PL providers declare that for them, Big Data does not provide solutions for significantly improved, data-driven decision-making. There are several papers describing the process of information and data retrieval. [McC13] explains which Big Data processes may matter in the area of Transport Management Systems. These are, e.g., cleansing, harmonizing, combining and standardizing data, as well as data visualization. [Ali12] described the way of gathering information by crowdsourcing. The use of Geographical Information System is examined by [Mil13], who also indicates sensors, GPS and social media as new data sources for the transportation industry. The study by [MGI11] explains how information can be collected through new technologies like smartphones or GPS. The customer could use such data for smart routing, car monitoring and localized services. But this also holds benefits for the government (e.g., urban planning) and companies (e.g., localized advertising, optimized routing). [MGI11] further on provides useful information for companies and governments how to start with Big Data.
Although Inventory Management/Warehousing was no major topic, we give a brief overview of the two analyzed papers. The first paper describes how the analysis of Big

[2] http://www.sas.com/

Data can be used to optimize the flow of packages in a company, and how to use this for simulation. The findings could serve to plan and develop new distribution centers. The simulation leads to a more proactive approach [Tre13]. The second paper describes a scenario in which data gathered from barcodes are analyzed to reduce storage capacity and distribution [MGI11].
A detailed view on further analysis (e.g. the technologies and systems generating the data) can be accessed via http://uwi.uos.de/att/BDL-LiteratureConceptMatrix.pdf

3.2 Case Study Research Results

Overall, we identified 14 case studies, which we analyze in this section. Similar to the paper analysis, we grouped the case studies into three main thematic areas, namely transport (79% of the case studies), SC (14%) and manufacturing (7%). To allow for a deeper insight, we briefly summarize the case studies in table 3.

Name	**Description**	**Data Sources**	**Addressee**
Barcelona	The City of Barcelona analyzes Big Data collected from social networks, GPS signals and government systems. These data can be used to analyze the flow of people or visitors in case of festivals in order to identify the most suitable places for bike rental systems (bicing) or to arrange for adequate public transport. Furthermore, the data help to better respond in case of emergencies because the city is well-informed of the urban environment and agglomeration areas etc.	Social Networks, Mobile Apps, Websites, GPS, Government Systems	Departments (Employees), Citizens, Tourists
http://www.microsoft.com/casestudies/Microsoft-Excel-2010/City-of-Barcelona/City-Deploys-Big-Data-BI-Solution-to-Improve-Lives-and-Create-a-Smart-City-Template/710000003415			
Barnes&Noble	Barnes & Noble (B&N) use Big Data. They run a portal through which their suppliers are granted insights in their sales at B&N without having to buy software.	Business Data	Supplier
http://public.dhe.ibm.com/common/ssi/ecm/en/imm14097usen/IMM14097USEN.PDF			
Big Data in Logistics	The DHL Smart Truck is used to optimize route planning. Initial planning can dynamically be adjusted through data from current orders and traffic conditions. This results in CO2 and cost reduction by saving miles.	Business Data (Order, Shipment), Traffic Data	Employees (Truck Driver)
http://www.dhl.com/en/about_us/innovation/research_development/bigdata.html			
Daimler FleetBoard	The Daimler Fleet Board allows for the real-time analysis of data from vehicles, such as status, position, charge and order data. The data can be used for various purposes, e.g., to schedule maintenance by predictions or to identify the eco-efficiency of the drivers or vehicles. During use of the vehicle, the drivers are provided with information contributing to	GPS, Telematics, Business data	Employees (Truck Driver, Management)

	the improvement of the driving style. The software also grants comparisons with other companies (benchmarking).		
http://public.dhe.ibm.com/common/ssi/ecm/en/nic03008deen/NIC03008DEEN.PDF			
FleetRisk Advisors	Different data, like working hours, telematics data (distances, times) as well as data from the drivers are collected for risk analyses. The software provides risk assessments for each driver. Such information allows the company to detect drivers who bring about an increased risk of accidents.	Telematics, Business Data,	Employees
http://public.dhe.ibm.com/common/ssi/ecm/en/ytc03278usen/YTC03278USEN.PDF			
General Electric (GE)	GE installs sensors in its products (jet engines, turbines, trains) to make the items smarter. Thereby, the customers are supplied with real-time data that can help to improve services (i.e. optimized maintenance times).	Sensors	Employees, Costumers
http://sites.tcs.com/big-data-study/ge-big-data-case-study/			
Jet Airways India	Jet Airways India analyzes diverse data sources to provide accurate information on the carbon footprint for reporting to the EU. The analysis is broken down to the aircraft level and also takes into account the consumptions during maintenance activities.	unknown	Employees, Government
http://public.dhe.ibm.com/common/ssi/ecm/en/ytc03528usen/YTC03528USEN.PDF			
KTH	The KTH University in Stockholm (Sweden) collects various data from GPS, automotive radar sensors on roads, transport fees and weather in order to calculate the expenditure of time it takes to get from one place to another. Based on the data, different alternatives can be evaluated to optimize traffic within a metropolitan area.	GPS, Radar Sensors, congestion charging, weather, etc.	Researchers
http://public.dhe.ibm.com/common/ssi/ecm/en/imm14097usen/IMM14097USEN.PDF			
RabbitMQ	Lucid Logistics provides software to collect data from trucks (e.g., GPS). The data can be accessed by their customers via a SOAP API in real-time and can be used for own analysis.	GPS, telematics	Employees, Costumers
http://blog.gopivotal.com/case-studies-2/case-study-shift-from-delayed-polling-to-real-time-telematics-with-rabbitmq			
Schneider National	Schneider collects data from sensors in trucks for the measurement of position, road behavior, current fuel capacity and amount of charge. The data are used to optimize refueling: Based on the fuel level, the target, the gas stations (and prices) on the way, the software recommends	Sensors, GPS	Employees (Driver, leader)

	the best fuelling station. Further analyses like driving behavior are possible.		
http://www.sas.com/resources/asset/Big-Data-in-Big-Companies.pdf			
StatSlice	A provider of SCM and logistics services in the automotive industry was forced to constantly respond to customer requests. Through the implementation of a data warehouse with an interface for customers for real-time data analysis, this burden was eliminated.	Business data (various source systems)	Costumers
http://www.statslice.com/case-study-series-auto-industry-logistics-provider			
TimoCom	TimoCom analyzes data from the largest European freight and vehicle exchange portal. The results are delivered in real-time and provided to customers free of charge. These data are for instance used for pricing negotiations.	Business data from website	Employees (Management), Costumers, Press
http://www.pentaho.com/sites/default/files/uploads/resources/timocom.pdf			
UPS	By means of telematics sensors, UPS measures data, such as speed, direction, braking and drive train performance to optimize routes in real-time. In 2011, this resulted in the saving of 85 million miles (or 8.4 million gallons of fuel). In future, the data will also be used to optimize the over 2000 daily flights.	telematics sensors, online map data, Business data	Employees (Trucker)
http://www.sas.com/resources/asset/Big-Data-in-Big-Companies.pdf			
US Xpress	US Xpress analyzes various data (GPS, telematics data of trucks and data collected through drivers' tablets (e.g., via camera)). One major goal is to minimize waiting times for drivers/trucks, which can be achieved by providing real-time information to the user. They also perform a social network analysis to evaluate the drivers' opinions on the software.	GPS, telematics, video camera, GPS, business data	Employees (Trucker, Management)
http://www.computerweekly.com/news/2240146943/Case-Study-US-Xpress-deploys-hybrid-big-data-with-Informatica			

Table 3: Overview of Big Data logistics case studies

Sensors, telematics and GPS seem to be the most important data sources. The gathered information is mainly used by the companies themselves, not for the costumers.

3.3 Expert Interview Results

The five experts have been interviewed in four conversations. In this section, we want to reflect the main statements.

The first interview reveals that the company has not yet explicitly addressed the topic Big Data. However, it offers a web platform on which their customers can analyze data in near real-time. The data are gathered from traditional business systems like transport management systems and SAP. All data persist in relational databases in a company-owned data center. The bulk of data is stored only (mostly requested by costumers) and

has not yet been evaluated.
The interviewee thinks that appropriate knowledge/skills and staff are essential success factors for the implementation of Big Data: “If you want to be successful in online trading, you must be in a position to collect large amounts of data and to create reasonable evaluation algorithms, so as to ensure that the customer receives the requested data within the shortest period of time.”.

The company of the second interviewee is planning pilot projects on Big Data. But already now, a lot of data analyses are executed in near real-time. For this purpose a data warehouse management system (DWMS) is used in which data from different sources are loaded. Data are stored in different relational databases (DB2, Informix, Oracle) while QlikView20 is used as BI solution.
All analyses are focused on process optimization. “[…] it helps to be able to transparently illustrate the decision makers what is currently happening. Thus, the speed of decision-making can be raised.” For faster analyses a NoSQL[3] buffer layer is planned, which should enable near real-time access (15-30 minutes). A faster availability is not cost-effective at the moment. The company identified several success factors and restraints, such as lack of skills and poor adaptability of existing software solutions. The full support of the management as well as the collaboration of IT and the different departments is seen as essential. Potential fields of operations are seen in the warehouse control and workforce management, as these are essential cost-driving factors. "It is about getting the whole SC transparent per customer or per location, detecting bottlenecks or identifying problems early, but also to recognize reciprocal effects of various processes. This is in my opinion the key to success." Benefits may be improved staff scheduling and increased customer satisfaction by keeping them constantly informed.

The third company has been working on the analysis of structured and unstructured data for 10-15 years. Currently, the two interview experts are working on the implementation of a central intranet platform. Customer data, orders, GPS data are additionally stored to data from business software. The data are used by systems like a DWMS and web portal, as well as warehouse and air, sea and road management. As management support is mandatory, its awareness for restructuring had to be increased. The use of Big Data in the data-rich areas (transport and warehousing) may lead to competitive advantages.
The third expert of the company reported on another project. To optimize warehouse logistics, the company has been working in the field of Complex Event Processing (CEP) as part of a pilot project. First forecasts are positive but measurable results have not yet been achieved. Another pilot project with explicit reference to Big Data will be launched in 2014.
Again, unexamined data are stored for future analysis (e.g. further development of CEP or Big Data pilot project). Recent analysis via DWMS is available within an hour, while CEP nearly achieves real-time.

[3] NoSQL = Not only SQL; SQL = Structured Query Language

The storage and transport logistics are considered as the most promising areas for real-time analysis. Production costs could be reduced and production quality could be raised by early detection of faults.

The full interviews can be downloaded at: http://uwi.uos.de/att/BDL-InterviewTranscripts.pdf

4 Discussion of Results

Regarding to RQ1, this research reveals that the topic of Big Data in logistics is still in its infancy. Our open search resulted in only a small number of scientific papers. Two main areas (transport and SC) could be identified, others remain rather unattended.

Especially in the area of warehouse management, we expected a high data volume (through barcodes, RFID, robots and sensors) and thus a large base of literature. To uncover potential opportunities, we recommend starting research in unexplored areas like warehousing. Due to the wide scatter of topics in the two main areas no focus or trend could be identified. Most of the papers are rather technical or describe possible use cases. Acceptance and behavioral research are completely missing. This research should be carried out in areas where Big Data projects have already been implemented.

The case study research offers a similar picture. Again, SC and Transportation are the largest areas, nearly 80 % of the case studies deal with transportation. The result of the literature review is assisted by the case studies. Especially in the field of transportation, there are many cases where data are collected from various sources (sensors, GPS, even social networks), and used for analysis. The analysis is often applied for optimized routing or recognizing driving behavior. Thus, the information achieved will be directly consumed in the company and used for process optimization. Concerning RQ2, Big Data, especially the analysis of various data sources like sensors, GPS and tags, is demonstrated in some cases in the realm of transportation. In other logistics areas it is widely under-represented.

The impressions of the literature review and case study analysis are affirmed by the results of the expert interviews. Again, a lot of data are collected from different sources, but there is a lack of analytical possibilities, often due to missing (costly) infrastructure. The use of near real-time information is seen as sufficient in most companies. The benefits do not justify the disproportionate costs for real real-time. There are no real business cases among the interviewed companies. Referring to RQ3, potential is seen in the field of transport (which coincides with the literature analysis and case study analysis), as well as in the area of warehousing. The gathered information should mainly be used by decision makers. Management support and trained staff are seen as essential success factor in Big Data projects.

5 Conclusion

This contribution captures the status quo of Big Data in logistics by means of a literature review, a case study analysis and expert interviews. However, there are some limitations in our research. Less than one third of the identified articles are academic. And although we identified several case studies of good quality, we may have missed others due to the ranking of the Google results. The expert interviews were conducted in Germany and thus only reflect the domestic image.
Although Big Data is still in its infancy in research and practice, there are some initial experiences in transportation and SC. From the analysis, the following implications for research and practice are derived.

Main Contributions and Implications for Science

1. Initiate research projects
   There are more practical examples than scientific articles. Thus, researchers are to be encouraged to conduct research on the relevant topic Big Data in logistics. Especially the use of technologies like tags (RFID, barcode, etc.) and ubiquitous computing (mobile phones, smartphones, etc.) and the use of data generated in the web (social networks, blogs, etc.) is not investigated in detail, as most paper concentrate on the use of business data (cf. concept matrix provided in section 3.1).
2. Interdisciplinary research
   Often, the technical side is in the foreground of Big Data research. We therefore call for an interdisciplinary research, which is composed of the areas of Information Systems, Computer Science, Statistics, Business Management as well as Social Science.
3. Relevant research
   To avoid irrelevant research, practitioners should be integrated into the research process as early as possible.
4. Explore new areas
   In addition to the already partially established areas transportation and SC, the research should also explore new areas. E.g. a warehouse management system can be enhanced by the data of various sensors installed in the warehouse or the products itself. In this controlled environment the use of technologies like tagging (barcode, RFID, etc.) can be used in a valuable manner.
5. Measure user acceptance and behavior
   Since there are already implemented Big Data projects, advanced research in these areas can take place, e.g. investigate how the behavior of the user has changed and whether the technology is accepted.

Main Contributions and Implications for Practice

1. Build a Big Data strategy
   As technical burdens are overcome, first Big Data projects can begin. The target should be to identify how Big Data can improve management decision or daily business. Case studies can be used to identify practices and technologies used by other companies; however a best practice had not been established yet. In case of transport and supply chain management there are several use cases which can be used. In case of warehouse management or production only innovators should introduce Big Data projects as there is no reference.

2. Management Support
   Since Big Data may change processes, an adequate change management and management support in Big Data projects is essential.

3. Include departments
   It is important to understand what the user wants. Therefore, department staff should be integrated into the projects as early as possible and a holistic approach should be followed.

4. Staff & Skills
   In addition to the technical side (knowledge in information systems used for Big Data Analysis), employees who deal with Big Data (e.g. data analysts) also need to understand the processes (domain knowledge) and possess analytical skills. Therefore, appropriate training or hiring of new staff is needed.

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