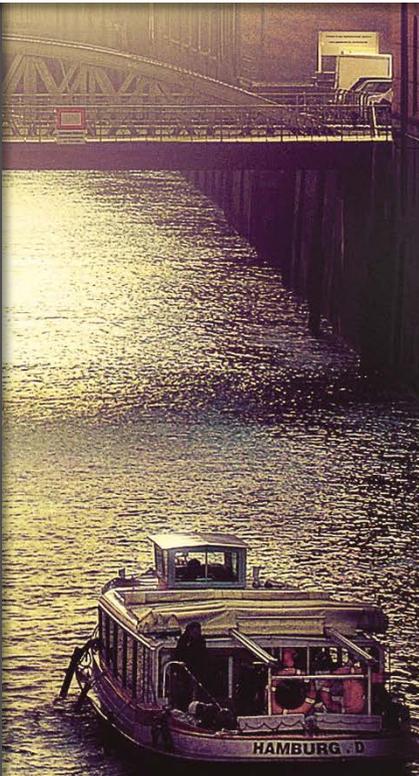


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Lead-time Optimization Potential of Digitization in Air Cargo

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*The air cargo supply chain consists of several parties: the forwarders collect air cargo shipments and consolidate these shipments in regional warehouses all over the continent. They decide upon the export airport and bring it there to consolidate all shipments in their air cargo hub - warehouse according to the chosen flight. Using local truckers, the shipments, consolidated by airline, are forwarded to the handling agents to load air cargo containers or to build up air cargo pallets. The containers or pallets are brought to the apron and loaded into the planes. There is not a single chain existing; the parties involved are part of a dynamic $n * m * o$ network which is fixed with every single shipment. The problem addressed in this paper is to document the waiting times at the level of the handling agents. Own, long time research at Frankfurt International Airport shows, that the waiting time for the trucker in front of handling agents warehouses significantly influence the lead-time for shipments. We identify the barriers to a faster adaption of digitization, which is currently around 30% in Frankfurt. Quantifying the impact of waiting times and required warehouse space due to long lead-times allows for a cost estimate.*

Keywords: Air Cargo; Lead-Time Reduction; Digitization; Air Cargo Supply Chain

1 Introduction

1.1 Problem description

In this paper, we address the optimization potential in air cargo handling by using electronic data exchange and the barriers that hinder a faster development of digitization. Digitization is expected to be an important enabler to optimize the physical shipment flow between forwarder and cargo handling agent and reduce existing waiting times.

As waiting time costs accumulate to millions of euros per year and the existing IT systems provide interfaces to exchange information between the participants of the supply chain and other solutions like cargo community systems exist, we try to identify the reasons for the slow adaption of digitization in the air cargo supply chain, mainly for forwarders and cargo handling agents.

Based on a survey within the members of the air cargo community of a major hub airport we can show that the benefits of electronic data exchange in the air cargo supply chain are well understood, but other barriers hinder further development.

1.2 Air Cargo Supply Chain

Air cargo is the fastest mode of transport, but also the most expensive one. It is therefore used in emergencies or in the global supply chain of high value goods. General air cargo has to be differentiated from express and parcel services – e.g. from DHL or UPS – as these companies mostly use dedicated air and road transport networks and facilities. The air cargo supply chain on the other hand consists of several parties: the forwarders collect the shipments from the shipper and consolidate these shipments in regional warehouses all over the continent. They decide upon the export airport and bring it there to consolidate in their air cargo hub-warehouse all shipments according to the chosen flight. Using local truckers, the shipments by airline are forwarded to the handling agents to load air cargo containers or to build up air cargo pallets. The containers or pallets are brought to the apron and loaded into the planes (see figure 1).

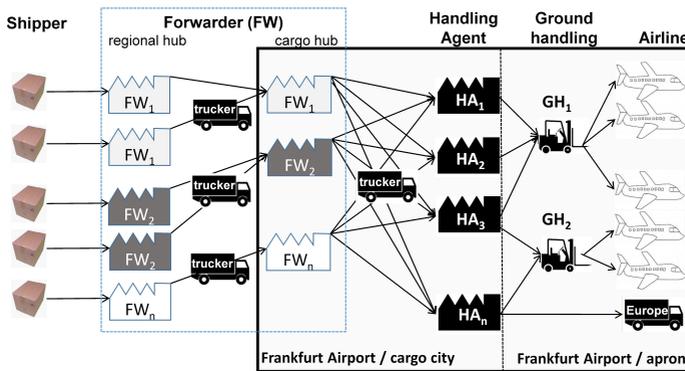


Figure 1: Air Cargo Supply Chain at Frankfurt Airport (here: export process)

1.3 Legal Situation between Forwarder und Handling Agent

The transportation is based on a contract between shipper and consignee where the respective party – according to the chosen INCOTERMS – orders the forwarder to organize the transportation. Besides of having outsourced various steps in the ground transportation. The forwarder is responsible for contracting an airline. The airline has their own contracts with handling agents at the respective airports (see figure 1). This leads to common supply chain management problem that at the handling agent's warehouse to parties meet which do not have a direct contractual relationship and therefore show only limited interest in mutual optimized solution. In difference to many production or distribution supply chains, a leading partner that forces its partners into a hierarchical supply chain management is missing. With many partners of various sizes and a volatile setup, also a consensus based supply chain approach is difficult to realize.

1.4 Digitalization in Air Cargo

The air cargo shipment has to be accompanied by many shipment papers, which are necessary for e.g. declaration or description of the content. This paperwork

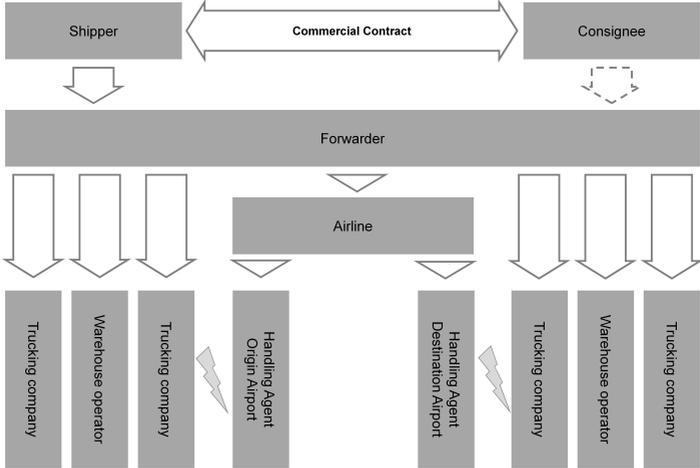


Figure 2: Contracts in the air cargo supply chain



Figure 3: IATA eAWB development (International Air Transport Association, 2017)

could be done electronically. The respective factors (papers transmitted electronically/papers in total) in Frankfurt differs from airline to airline, from forwarder to forwarder, but does not exceed 30% so far. Penetration rate of electronic airway bills (eAWB) just reached the global 50% mark and is lagging behind the expected development. Several activities have been conducted, e.g. by the International Air Transport Association (IATA), or the local collaboration platform fair@link to increase the digitalization share, but did not show fundamental success by now (see figure 3).

1.5 Weekend Peak

Around half of all cargo is transported on passenger planes, which often offer a daily (or better) service to major destinations. Nevertheless, cargo volume typically peaks on weekends. As most businesses (shippers and consignees) do not operate on weekends the shipments arrive on Friday or Saturday latest for export and the incoming shipments will be picked up Monday morning. The weekend peak is especially challenging for the handling agents, as air cargo shipments are typically booked on short notice (see figure 4).

1.6 Key Performance Indicators in Air Cargo

In air cargo handling, competitiveness can be defined by lead-times and related costs. Lead-times directly influence the related costs as shorter lead-times re-

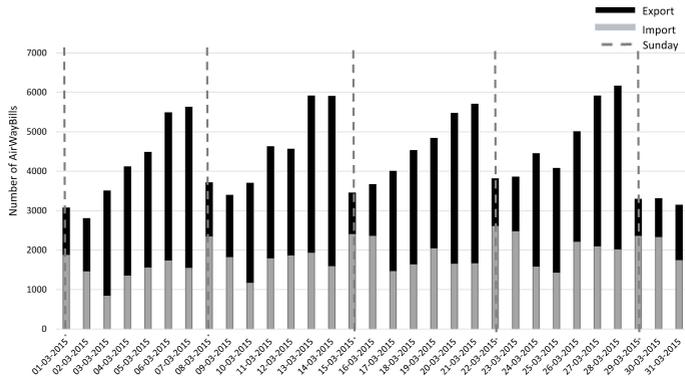


Figure 4: Weekly cargo volume distribution (n = 102,793 Airway Bills of March 2015 = 40% of Volume of Frankfurt Airport)

duce the number of stored shipments in the warehouse and – besides being less complex – allow for an increase in efficiency.

The lead-time concerning this paper is defined to be the difference between the arrival time of the truck at the office of the handling agent (landside) and the transportation of the shipments to the plane (airside) for the export process. The lead-time in imports is measured between the arrival of the shipments at the handling agent's warehouse on the airside and the pickup by the forwarder.

1.7 Structure of the paper

This paper is organized as follows: The related literature from the areas of air cargo, supply chain management and operational logistics is presented in section 2. A detailed problem description follows in section 3. It is based on other research about truck waiting times and average lead-times in handling agent warehouses before detailing the theoretical benefits of digitization and potential barriers or risks.

Section 4 contains the relevant information about the setup and structure of the survey, which is followed by the presentation of the most important results in section 5. These are transformed into a benefits-barriers-model. Section 5 ends with a critical appraisal of survey and model. The last section contains a summary and directions for further research.

2 Related Literature

2.1 Aviation and Air cargo

Research in the Aviation industry is mostly focused on the passenger transport (Wittmer, Bieger and Müller, 2013).

Specifically in air cargo networks only few current research papers are found (Sieke, 2010; Vancroonenburg, et al., 2014; Feng, Li and Shen, 2015a; Zhang, et al., 2017) which contain mostly pure theoretical considerations without containing real data.

Chen et al consider the choice of optimal transshipment-hubs (e.g. that of the export port or the airport) from the shippers and forwarders perspective (Chen, et al., 2017). Besides quantitative factors such as costs and transportation distance, location-specific qualitative elements are taken into account as well. Feng (Feng, Li and Shen, 2015b) gives an up-to-date overview of the air cargo operation. The examined questions are about the optimization of the layout or separate processes (Frye, 2003; Chan, et al., 2006; Yan, Shih and Shiao, 2008; Bierwirth, 2009; Lau, et al., 2009; Selinka, Franz and Stollitz, 2016). Other authors examine the Revenue Management in air cargo (Hellermann, 2006; Pfeffer, 2015; Chao and Li, 2017).

There are some, partially unpublished, preparatory works by the authors that talk about the investigation of the processes at Frankfurt Airport (Wagschal and Schocke, 2012; Schocke, 2013; Hertelendy, et al., 2015; Wegener and Schocke, 2015; Bierwirth, Höhl and Winning, 2016; Schocke and Koch, 2017).

2.2 Supply Chain Management

Beside Air cargo specific processes research and publications regarding the benefits of information exchange in supply chain management is relevant for the deduction of digitization benefits.

The majority of the publications focuses on a classic Supply Chain and the cooperation of supplier, producer, distributor and examines the effects of fluctuations in demand and the resulting costs (Schulze, 2009; Barros, et al., 2015; Marinagi, Trivellas and Reklitis, 2015; Rached, Bahroun and Campagne, 2015). Walter (Walter, 2015) examines the “Exchange of information in the maritime transport chain – investigation of process performance in the data flow of capacity utilization” in very similar and comparable aspects. Aspects of empirical investigations were transferred to air cargo based on this publication.

Only in Walter (Walter, 2015), the relations of associates inside the transport chain (forwarders, carriers, other logistics service providers) were object of a publication. The quantification of use mostly occurred over simulation models and calculations and was only seldom linked to empirical analyses.

Consisting approaches from the SCM-theory prove that a corporate planning policy such as e.g. a mutual optimal order- and production policy can be determined in ways of minimizing the sum of total costs from customer and producer (Sucky, 2004).

2.3 Operational bottlenecks

In theory and practice, loading ramps are known to be a bottleneck of transport logistics. Many practice-oriented publications of the recent years in this context make it clear that friction losses occur in the interfaces of processing (Semmann, 2012). The site operating companies, here Handling Agents, aim for maximal capacity of their ramps and a continuous flow of cargo (Semmann, 2012). Ramp management concepts aim for an optimization of the use of the ramps. In practice, the active management is often not transcribed in consideration of all boundary conditions, which leads to efficiency losses. These losses can affect the daily planning substantially of the site operating and cargo carrying companies and are not only complained about in practice but also talked about in a special report of the federal office for freight transport (Semmann, 2012).

3 Problem Description

Firstly, we describe results of the research about the status, which give an indication about the optimization potential. Afterwards the benefits of digitization and electronic data exchange will be detailed and potential risks discussed.

3.1 Current status and deficits

According to proven supply chain management theory, the exchange of information between supply chain partners – in our case the forwarder, the airline and the handling agent – could accelerate handling as all parties can prepare in advance and optimize their use of resources. The minimum improvement would be the time saving of entering shipment or airway bill data and avoidance of printing and paper costs. Beyond these simple references, a more detailed approach regarding the benefits of electronic data exchange is missing. Besides formulating, the urgent need for digitization related risks as well as needed competencies and capabilities necessary for successful digitization are unknown.

Earlier research showed that the parties involved (handling agents and forwarders) use IT systems, which are capable of exchanging information in various formats and to a centralized platform as well as over bilateral interfaces.

An on-site observation of the truck docks of several handling agent warehouses over a period of 36 hours at 1st and 2nd of June, 2017, led to the calculation of average truck lead-times.

The overall lead-time for handling agent 1 is 186 minutes, for handling agent 2 209 minutes and for handling agent 3 is 164 minutes. Supposing an identical mix of shipments and defining the shortest length per segment as a benchmark (e.g. 39 minutes for handling agent 2 company arrival - office entrance), the benchmarking lead-time is 88mins. Consequently, significant waiting times can be calculated: at least 50% of the overall lead-time is waiting time (see figure 5).

As part of the observation, the truck drivers have been asked, if they announced their arrival (e.g. using a truck dock scheduling system) or if they have been informed about the current operating grade at the ramp. Just 25% of the truck driver use existing ramp scheduling systems and 25% are informed about current operating grade. This happens although 80% of the truck drivers are equipped

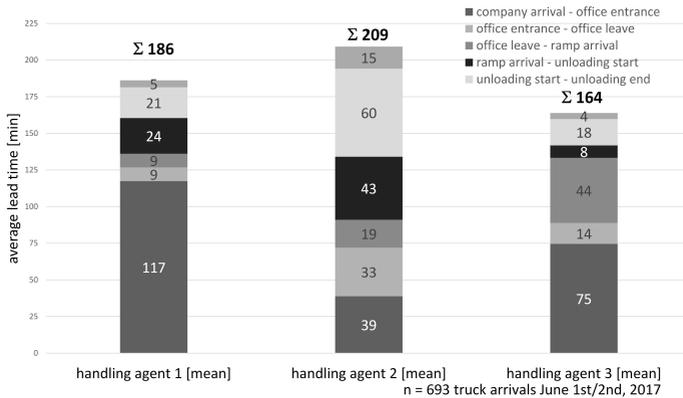


Figure 5: Truck waiting times as part of lead-time

with a smart phone. Exchange of information does not happen and leads to long waiting times.

Beside the cost of waiting times, the missing information about the shipments loaded onto each truck some shipments miss their booked flights which causes extra costs. Expectation of several partners of the air cargo supply chain is that with electronic data exchange and a truck slot time management system these backlogs (see chapter 5).

Apart from observing truck drivers, we collected a set of data from four handling agents and Fraport from March 2015, which covers 40% of the overall tonnage. With this set of data, we are able to calculate the lead-time from office entrance at handling agent until off block (plane leaves its parking position).

The analysis of the lead-times of these 102,793 shipments show that while the mean is almost a day (from delivery to airside departure and airside arrival to pick up) most cargo is delivered or picked up shortly before latest acceptance time (LAT) or after time of availability (TOA). It can be logically deduced that shipments which arrive early or stay long in the handling agents warehouse add to the complexity and may block resources which are needed for time critical shipments. As with the time management system the expectation is the increase

the efficiency of the use of resources and faster processes at this external interface with digitization (import: see figure 6; export see figure 7).

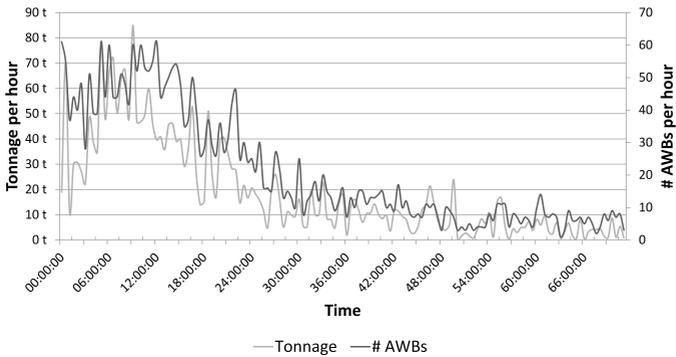


Figure 6: Import lead-times

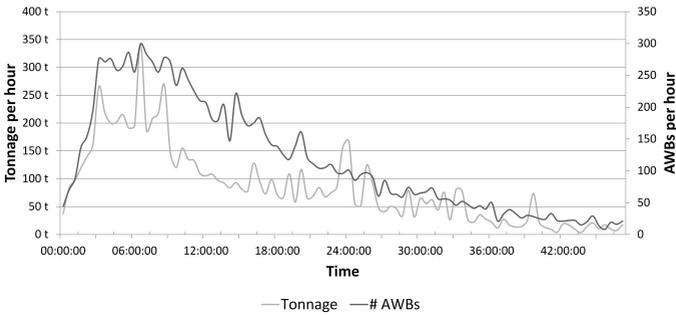


Figure 7: Export lead-times

3.2 Benefits of digitization

As mentioned in the beginning, the overall expectation would be cost saving. However, beside this and the above-mentioned expected increase in resource efficiency further aspects have to be considered as benefits (see figure 8).

Based on a better planning which is made possible by information transmitted prior to truck arrival processes can be aligned and thereby reducing waiting times, so a faster process can be achieved (time). At the same time, the amount of time for re-entering the data can be eliminated. The planning leads to a more efficient use of staff and less waiting times or buffers between various process steps and thereby accelerates the handling.

Reduced lead-times increase the use of truck docks and storage area, so overall capacity of the facility can be increased. The resources involved are used more efficiently at the same time and thereby the marginal costs are reduced.

The benefits regarding the cost perspective is threefold: As already mentioned the cost for re-entering data can be eliminated. This also eliminates possible mistakes and the related effort to correct those. Less mistakes than lead to less effort for searching and/or questions by customers. Additionally the more efficient use of staff leads to reduced costs.

Not only less mistakes are made, but also mistakes could be identified earlier (e.g. if number of packages differ with documentation).

Last factor to be considered should be a positive effect on the image of a handling agent as less mistakes may lead to higher customer satisfaction.

3.3 Risks and required competencies

As the benefits are easy to deduct, although not quantifiable, additional barriers or other missing elements are hindering a faster adoption.

Based on several expert interviews and students' thesis as well as the authors experience over the years, the authors identified risks and competencies that might be crucial for a successful digitization.

A very important aspect is trust in the partners and service providers or fear about the misuse of information provided electronically. This mainly defines the willingness of exchanging data. This aspect than is of course the ability to

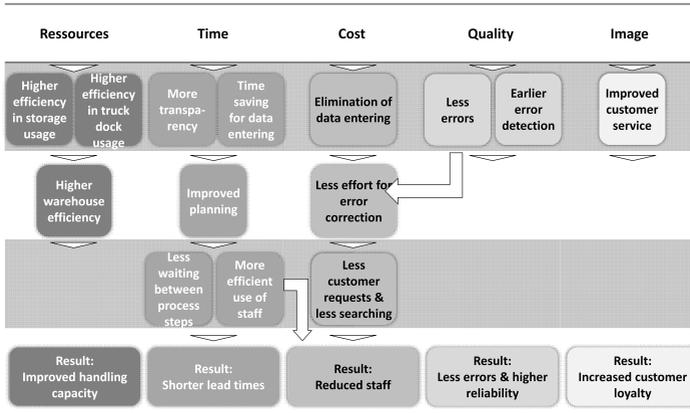


Figure 8: Detailing the benefits of digitization in air cargo

exchange data, which requires technical and management skills – from connecting the systems to explanation of the transformation to the employees.

4 Survey

The survey within the air cargo community was designed to firstly verify the understanding of the formulated benefits of digitization. The second part deals with the other aspects, the risks and competencies such as the digital readiness of partners in the air cargo supply chain and their supply chain thinking.

As electronic data exchange requires at least two parties (sender and receiver), the survey should be relevant for all parties in the air cargo supply chain, and not specified for one group.

The survey consisted of 40 questions which were sent to members and interested parties of Air Cargo Community Frankfurt (ACCF). In total 136 persons were addressed. Prior to that, the questionnaire was pre-tested within in the project team and with selected members of the community. A return rate of 26% could be achieved. The returning questionnaires cover the entire air cargo supply chain (see figure 9)

In the beginning, the participant had to select the company size and its role in the supply chain.

To evaluate the importance of model sub-elements the participants were requested to give their consent or opposition to statements on a scale from 1 to 10 where 1 was defined and indicated as “I totally disagree” and 10 as “I totally agree”. Additionally we integrated open questions and multi-selection questions, e.g. for the type of electronic data exchange that is currently used.

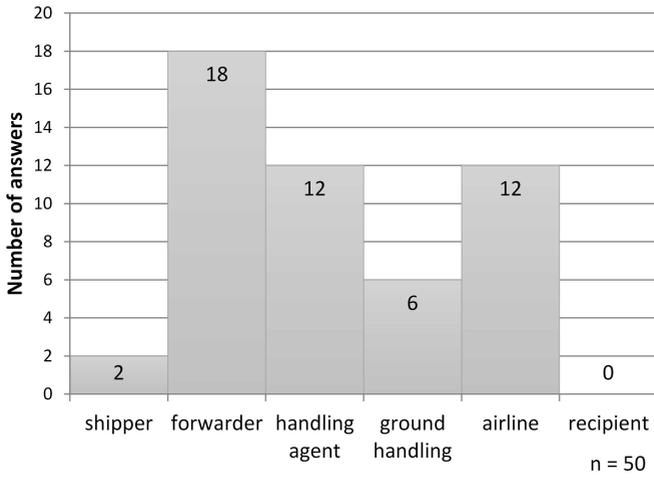


Figure 9: Position in air cargo supply chain of respondent (n=50)

5 Results

5.1 Benefits of digitalization

In part one of the survey, the respondents have been asked for their view on the benefits of digitalization.

Concerning the digital exchange of information, 85% of the respondents reported to already use digital data exchange (see figure 10).

In most cases IT-systems are connected via electronic data interchange (EDI), however, 24% of respondents said they mainly use e-mails with attachments. The tools being used are separated into one third each between the local cargo community system fair@link, bidirectional interfaces as well as other media (here especially e-mail clients)

The advantages of electronic data exchange are clear to the respondents. Digital data exchange improves resource utilization (mean 8,96; STD 1,33), reduces costs (mean 8,55; STD 1,64), improves data quality (mean ,67; STD 1,99) and makes it possible to increase capacity (mean 7,70; STD 2,03). Data exchange also strengthens the image of the company (mean 7.98; SRD 1,58).

5.2 Maturity of Supply Chain Thinking

The importance of general thinking as well as cooperation is being recognized clearly by the companies: The up- and downstream companies in the supply chain are seen as part of the own network (mean 7,58; STD 2,45; see figure 11)

As mentioned before companies see big advantages in electronic data exchange. But there is an obvious gap between desire and reality: Although practically all companies use electronic data exchange not all partner companies are attached (mean 7,58; STD 2,45; see figure 12).

5.3 Data quality

Reasons for the poor penetration of electronic cooperation are widely varied (see table 1).

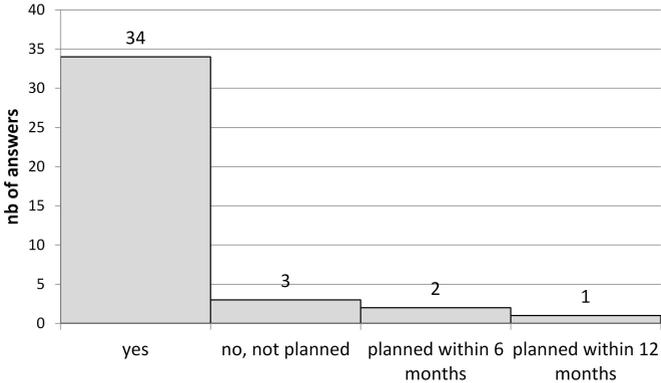


Figure 10: Usage of digital data exchange (n = 40)

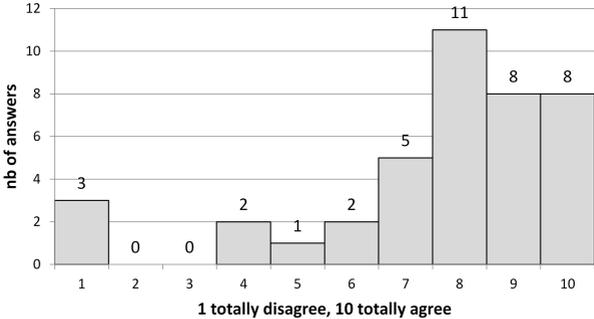


Figure 11: Downstream and upstream companies are part of companies supply chain

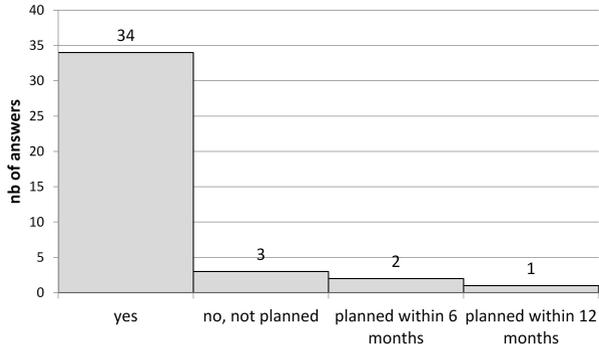


Figure 12: Direct connections between the IT systems of all our partners do exist

Table 1: Reasons for poor electronic penetration

Information we get is ...	Mean	STD	Median
In time	5,61	2,38	5,00
Complete	5,74	2,41	6,00
Reliable	5,91	2,31	6,00
Clear and easy to understand	6,14	2,26	6,00
Up to date	6,19	2,32	7,00

The information that is transmitted to the partners is unsatisfactory in several dimensions. Respondents see immense improvement potential in both punctual delivery and completeness and currency. Especially the aspect of reliability of data is seen critically. In addition, the rework of electronically transmitted data needs to be corrected by 26% of the companies.

The advantage of electronic transmission to avoid system breakdowns cannot be verified for sure; IT processes need to be checked manually which can lead to additional costs.

5.4 Risks

The contradiction between wanted and implemented electronic exchange of data can be shown by the means of two additional dimensions. On the one hand, digitization leads to transparency, on the other hand digitization is seen critically due to stronger dependence on IT.

The operative processes in the air cargo industry nowadays are marked by randomness and lack of transparency. The decision which airline sends a consignment is a case-by-case decision, which e.g. contains extensive requests for different airlines (see chapter 2). Through electronic linking of IT systems cargo data can be retrieved directly. At the same time, inefficiencies on individual value levels become visible to the customer. The companies however become more transparent and therefore better comparable in terms of the temporal component of the processes (see figure 13).

Therefore market transparency will increase, which most of the companies suggest (mean 7,24; STD 1,79). This transparency is seen more as a threat than a chance (mean 4,76; STD 2,74).

These statements are influenced by the thought that many IT projects are obviously unpredictable (mean 5,59; STD 2,58), the confidentiality of data can only be ensured conditionally (mean 5,76; STD 2,76) and one becomes dependent on one service provider due to linkage (mean 6,03; STD 2,78) or the connection is very complex.

In conclusion, a very heterogeneous picture is shown regarding the realization of digitization in the air cargo industry.

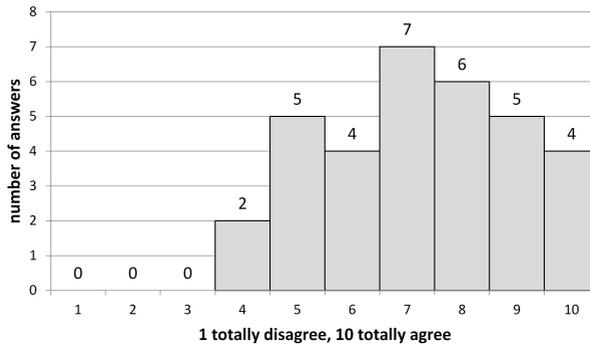


Figure 13: The market becomes more transparent

5.5 Benefits-Barrier-Model for digitization in air cargo

Based on the results of the survey a benefits-barriers-model was developed to reflect the potential benefits of exchanging data and the barriers the might hinder the successful implementation. Therefore, an inverted triangle was chosen to reflect the three perspectives: The five types of benefits can only be realized if the four competencies are present with a basic knowledge and the risk side can be calculated against the benefit (see figure 14).

As mentioned in section 3.3, the risk perspective mainly influences the willingness of a participant to share information. Related to the exchange or distribution of information on an exchange platform additional risks arise:

- The business might become more transparent
- The confidentiality of the information has to be ensured
- The partner may become dependent of the platform and the information provided

The (IT) project risk involves the uncertainty and lacking experience with projects – esp. of smaller partners. This could be solved with external partners providing

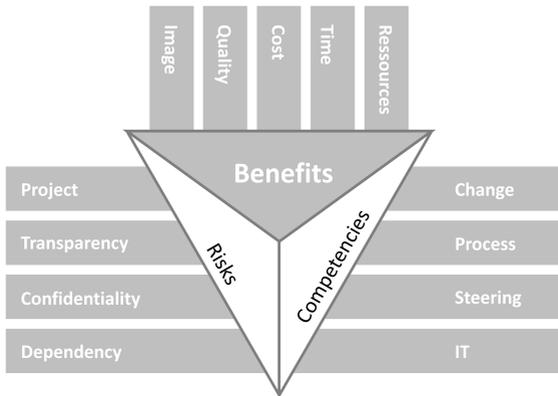


Figure 14: Benefit-Barriers-Model

this experience or by the exchange service provider who includes the project management.

On the competence perspective, a partner has to possess steering and process competencies. The information acquired earlier in the process has to be used to improve planning for example; otherwise, no benefits can be realized. The partners have to understand their IT system and the platform and how it integrates into the overall process and for example, which mobile equipment is needed. This is meant with IT competence. As commonly known digitization changes the working environment so an accompanying change management is essential for a successful installation.

5.6 Critical Appraisal

The model was developed based on a limited sample size of answers from just one airport community. The maturity of competencies is hard to measure and the model so far does not indicate which maturity level has to be achieved to take the competence barrier.

Quantified calculations of the benefits, e.g. from a best practice, are necessary to calculate a business case which is necessary in most companies to justify investments and projects.

6 Conclusion

The air cargo supply chain consists of many partners with individual goals, interests and perspectives. The grade of digitalization in information exchange is poor compared to other industries. We presented lead-time calculations as well as waiting time considerations which show the inefficiency of today's processes. We describe the discrepancy between these inefficiencies and the expectations of the protagonists of the air cargo supply chain.

We conducted a survey which shows that the benefits of digitization and electronic data exchange are understood and agreed upon by all participants in the air cargo supply chain. A positive impact on image and quality can be expected as well as reductions in cost and lead times. Resources can be used more efficiently.

The survey revealed a maturity in supply chain thinking although there is a huge gap between the perception of supply chain thinking and the existing electronic data exchange between the partners.

Beside predicting benefits from digitization and having a supply chain thinking other barriers hinder the development of electronic data exchange. Managers mostly fear the transparency of a digitized supply chain and lack some competencies for making the digital transition.

The results of the survey led to the development of the benefits-barriers-model. The benefits of digitization can only be realized if risks are low and other competencies exist.

Acknowledgements

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