DIGITALIZATION MODEL OF INFORMATION AND DOCUMENTS FLOWS IN GOODS MOVEMENT PROCESSES IN SUPPLY CHAINS - DETERMINANTS OF IMPLEMENTATION AND MEASUREMENT EFFICIENCY

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Abstract

Companies along the supply chain are increasingly adopting digitalisation solutions to improve the flow of goods and accompanying information. Among other things, the digitisation of supply chains aims to eliminate traditional paper documents and move towards Electronic Data Interchange (EDI). Electronic documents provide a standardised and automatic exchange of information necessary for e.g. ordering or delivery processes and enable a direct link between the flow of goods and the information concerning this flow. Ultimately, companies can achieve several benefits such as eliminating errors in manual data entry, eliminating delays in information processing, shortening the time of operations, and thus reducing their costs. In the paper, the authors present a model describing the digitisation of key documents in the process of order and service in supply chains and the concept of measuring the efficiency indicators of the implementation of the developed model.

The research carried out in this area is the result of cooperation between Lukasiewicz Research Network – Poznan Institute of Technology and Poznan School of Logistics. The research was conducted in 2021 and the first half of 2022 with a conceptual approach, pilot implementation and ultimately a benefits analysis. The research was performed as part of a research project carried out for GS1 Poland.

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Key words: paperless, information flow, supply chain digitalisation, supply chain efficiency

1. INTRODUCTION

Digitization of supply chains is a complex problem described in the academic literature at both the strategic (Canhoto et al, 2021; Ritala, et al, 2021; Wen, Zhong, Lee, 2022) and operational levels (Wiedenmann, Größler, 2019; Grooss, Presser, Tambo, 2022; Peschl, Schüth, 2022). Due to its complexity, it comprehensively touches on all aspects of supply chain business operations (Gray, Rumpe, 2015), from streamlining workflows in accordance with the Paperless concept (Šuleř, Machová, 2019), to integrating IT systems among supply chain business partners (Siagian et al, 2021), to applying digital technologies to improve logistics processes (Dujak, Sajter, 2019; Parhi et al, 2021; Wahab, Rajendran, Yeap, 2021; Fahad Anwar et al., 2022). Digitization of supply chains is also very often focused on improving the efficiency of individual logistics processes, i.e. optimizing transportation (Marchenko, Babyr, 2021; Palkina, 2022; Gaponenko, Hvoevskaya, 2022; Wycislak, 2022), streamlining production processes (Birkmaier et al, 2021; Thürer, Li, Qu, 2022; Sapel et al, 2022), optimizing warehouse processes (Borisova, Taymashanov, Tasueva, 2019; Winkelhaus, Grosse, 2022; Sgarbossa et al, 2022) and distribution (Burroughs, Burroughs, 2020; Parfenov et al, 2021).

Regardless of the complexity of the problem, digitalization is based on automating and streamlining supply chains and the flow of information between business partners. A way to affect the efficiency of logistics processes from a Paperless perspective is the use of Electronic Data Interchange (EDI). Among the basic EDI messages that affect the application of the Paperless concept in supply chains are:

- order (ORDERS),
- delivery advice/dispatch advice (DESADV),
- electronic transport order (e-CMR),
- delivery receipt (RECADV),
- invoice (FV).

There have been conceptual and implementation studies using EDI messages to streamline logistics processes and reduce errors affecting supply chain operations. The present research aims to start a scientific discussion on the benefits of digitizing logistics processes in supply chains.

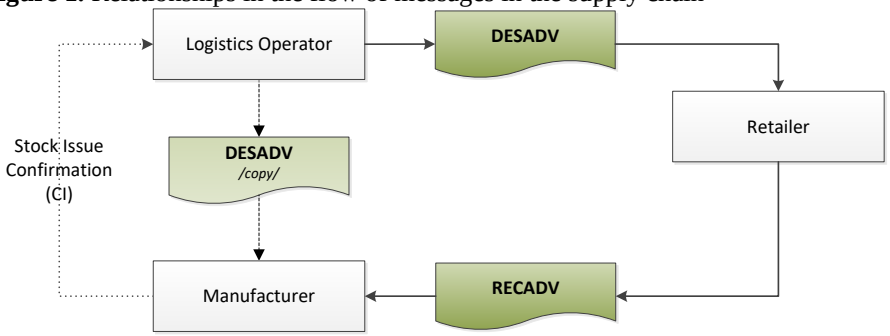
2. RESEARCH METHODOLOGY

The Paperless model developed as part of the research work had the character of a target model, taking into account the full digitization of document workflow in the processes of goods movement in supply chains. The research work carried out in this regard was aimed at identifying the benefits of implementing EDI messages as a solution in line with the Paperless concept.

In the first phase of the research work, a specific business case (supply chain) was defined, within which the implementation was to be carried out, and specific

documents were defined to be digitized. According to the research methodology, the pilot implementation covered the supply chain: Manufacturer - Logistics Operator - Retailer, and within this chain the DESADV and RECADV messages (Figure 1).

Figure 1. Relationships in the flow of messages in the supply chain



Source: Ł-PIT research

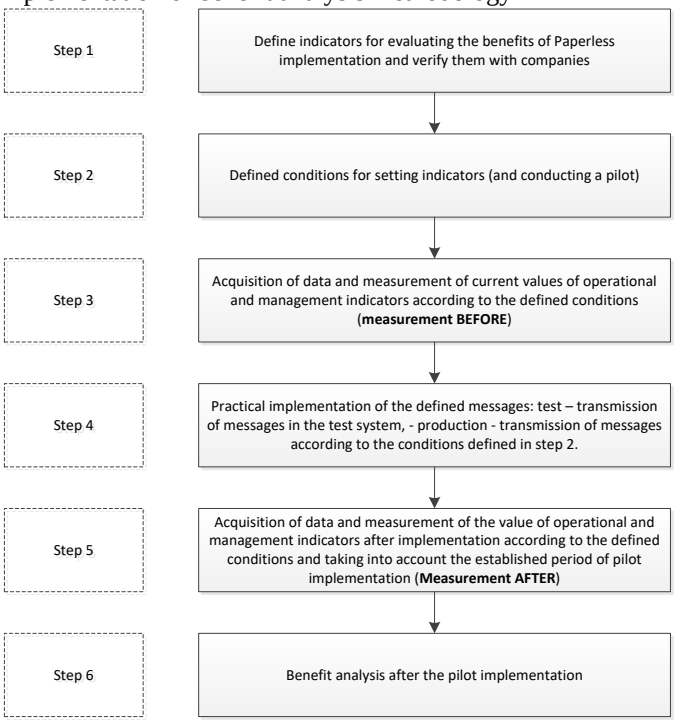
In doing so, it should be noted that the key document that was subject to implementation was DESADV. The RECADV message was also implemented in the relationship in question, however:

- The Retailer sends only a simplified structure of the RECADV electronic document, which does not allow for a full recording of discrepancies in delivery; the expansion of the information structure of the document will be able to be implemented only after the implementation of the WMS system in the Retailer,
- The manufacturer is carrying out work on its side to upload the RECADV document, to finally enable the automatic generation of FV for orders that have 100% fulfilment confirmed in RECADV.

Establishing the basic assumptions of the scope of the pilot implementation allowed us to define the methodology for analyzing the benefits of implementation, as shown in Figure 2.

This methodology is the basis for conducting analyses of the impact of using the Paperless concept on the efficiency of logistics processes in the supply chain. Benefit analysis by comparing the pre-implementation state and the post-implementation state in the same period allowed minimizing the risk of comparing different current states, caused, for example, by the seasonality of supplies from a given manufacturer, or sales peaks. The proposed benefit analysis methodology makes it possible to multiply this method of analysis to further partners in the supply chain.

Figure 2. Implementation of benefit analysis methodology



Source: own study

3. MEASURING THE SUCCESS INDICATORS OF THE PILOT IMPLEMENTATION

The pilot implementation refers to DESADV and RECADV messages, according to the established information structures, shown in Figure 1. The pilot covered all delivery orders executed by a given Logistics Operator (on behalf of the Manufacturer participating in the pilot implementation) during the established period (related to orders of the Retailer to the Manufacturer) and delivered to the Distribution Center of the Retailer. For each delivery order, related DESADV and RECADV messages will be generated, in the relationship:

- Logistics Operator→ DESADV →Retailer,
- Commercial Network→ RECADV→ Manufacturer.

Pilot implementation period (first indicated period of implementation of established messages, in established information structures):

- launch in the test system: 17.12.2021 - 01.02.2022
- migration from the test system to production: 02.02.2022

- production launch: 01.03.2022 - 30.03.2022:

Period of data for measuring indicators:

Taking into account the seasonality of commodity deliveries, it was agreed that the period for data collection BEFORE implementation should be analogous to the period during which the pilot is implemented (and from which data for OP measurement are taken) with a yearly offset. This approach will enable comparative analysis of results obtained at the same point in the seasonal cycle both before and after implementation.

Given this assumption and the realistic periods when the pilot was implemented, the following periods were defined for measuring indicators:

- measurement BEFORE implementation: March 2021 (01.03.2021 - 31.03.2021),
- measurement AFTER implementation: March 2022 (01.03.2022 - 31.03.2022).

Measurement risks:

The first period of pilot implementation may be a time when the full picture of benefits cannot be achieved due to the need for the company to adapt to the implemented solution and potential inefficiencies in the flow of implemented messages. Therefore, it is planned to repeat the pilot and measure its efficiency in an indicative manner after a longer period of application of the solution (e.g., in a sequence of 30 - 60 - 90 days after the initial launch).

This benefit analytics approach is due to potential process disorganization after the implemented deployment, the effects of which have a direct impact on the efficiency of the deployment. Conducting additional measurements in later periods will enable a comprehensive analysis of implementation efficiency, including the aspect of adaptation of the implemented solution to the implemented processes.

4. BENEFIT ANALYSIS OF THE PILOT IMPLEMENTATION

The benefit analysis of the pilot implementation was based on the indicators shown in Table 1.

Table 1. Indicators measured in the pilot implementation

Indicator	Manufacturer	Logistics operator	Retailer
Indicator of the use of EDI messages in the advancement of deliveries	X	X	X
Indicator of saving root of handling delivery from supplier			X
Indicator of delivery acceptance efficiency			X
Indicator of invoices issued based on RECADV	X		
Indicator of driver's stay at the recipient in the delivery process		X	

Source: Lukasiewicz-PIT research

The tables below include data provided by the Manufacturer and the Retailer. Data was obtained only from the two companies involved in the implementation process, the Logistics Operator was not able to provide data (e.g., monitoring the driver's time at the recipient in the process of delivery), in addition to the actual list of completed deliveries.

Following the accepted logic, monthly data were obtained after the implementation (March 2022) and data from the corresponding period in 2021 (March 2021), to realistically compare the results and assess the potential benefits of the implementation. The companies provided the aggregated monthly data needed to determine the defined performance indicators of the pilot implementation. The following summaries show the comparative results for each company.

Table 2. Data for deployment efficiency analysis - Manufacturer

Data type	Data from **BEFORE**	Data from **AFTER**
	March 2021 01.03.2021 - 31.03.2021	March 2022 01.03.2022 - 31.03.202
total number of deliveries for a given customer	110	99
number of returns	2	0
total number of deliveries for a given customer	110	99
monthly number of DESADV messages	0	99
monthly number of total advising documents	0	99

Source: Lukasiewicz-PIT research

Table 3 shows the aggregate results of the indicators generated for the Manufacturer.

Table 3. Implementation Efficiency Analysis - Manufacturer

Index	**BEFORE implementation**	**AFTER implementation**
Analysis of returns in deliveries*	1,82%	0,00%
Indicator of FVs issued based on RECADV*. /totalled to all FVs/	0	98,18%
Indicator of the use of EDI documents in the advancement of deliveries	0,00%	100,00%

Source: Lukasiewicz-PIT research

The primary benefit of implementing DESADV at a Manufacturer is the digitization of data flow and information about the timing and completeness of customer orders. The integration of the despatch advice with orders, sent by EDI message, allows us to suggest that the manufacturer can optimize the level of stock to be released, guided by the application of the Just in Time concept in stocking the warehouse with stock to be released, thereby reducing the cost of keeping the stock ready for release. However, the information obtained during the initial post-implementation phase does not allow to explicitly confirm this thesis, but in the future, it is worth keeping such a context in mind.

A very important conclusion was identified, pointing to the very high potential of implementing an expanded RECADV message as a consequence of the completed DESADV implementation. The RECADV message, which is an acknowledgement of receipt of delivery, will ultimately be the basis for invoicing for all deliveries. In the current situation, the Retailer only sends a simplified message that does not allow for the recording of discrepancies in the delivery, so the automatic issuance of an FV about RECADV is possible only for fully compliant deliveries, where there is no return. Both before and after implementation, a very low rate of non-conforming deliveries (return rate) was recorded in the Manufacturer - Retailer relationship: about 2% returns before implementation, and 0% returns after implementation. Translated into the billing process, this means about 98% of FVs are issued automatically, as soon as PZ is generated at the recipient and RECADV is sent. This generates significant time savings in the process of settling order fulfilment at the manufacturer (efficient and fast issuance of FV without the need to enter additional data and scanned documents into the system) and gives the potential to improve financial flows between the recipient and the supplier (faster issued FV = faster payment).

Table 4. Data for deployment efficiency analysis - Retailer

Data type	Data from **BEFORE**	Data from **AFTER**
	March 2021 01.03.2021 - 31.03.2021	March 2022 01.03.2022 - 31.03.202
total number of deliveries from a given supplier	152	133
average time spent accepting delivery from a given supplier [minutes]	55	31
number of EDI messages (DESADV) in a month	0	83
number of advising documents per month	152	133
the annual cost of handling the acceptance of deliveries	47 730,90 zł	18 017,00 zł

Source: Lukasiewicz-PIT research

Table 5 shows the aggregate results of the indicators generated for the Retailer.

Table 5. Implementation Efficiency Analysis - Retail

Indicator	BEFORE implementation	AFTER implementation
Indicator of incorrect deliveries from a supplier	43,42%	38,35%
Delivery acceptance efficiency rate [minutes]	55	31
Indicator of the use of EDI documents in the avowal of deliveries	0,00%	62,41%
Indicator of cost savings in handling deliveries from a supplier	5 244,00 zł	3 227,92 zł

Source: Lukasiewicz-PIT research

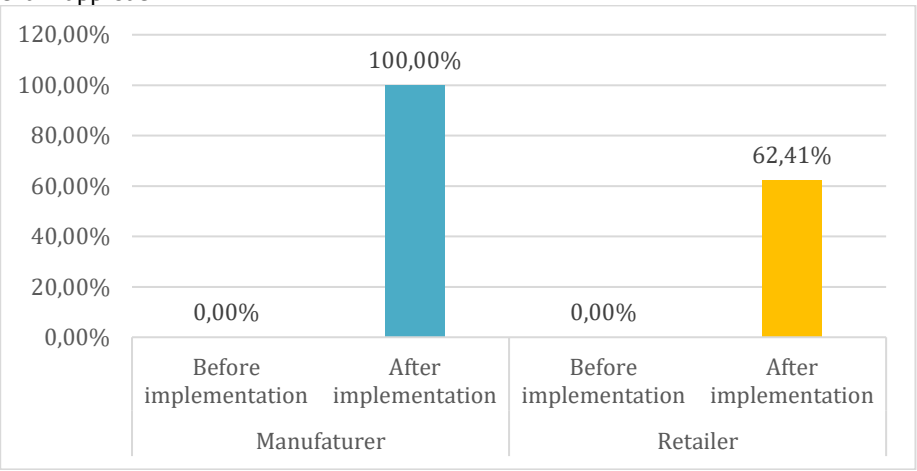
An analysis of indicators based on data from the Retailer shows that the rate of incorrect deliveries from the perspective of the Retailer has improved by about 5%, which should be considered a good result, but not directly conditioned by the implementation of DESADV. This is mainly due to a reduction in the rate of untimely deliveries. This rate, according to the Retailer, in March 2021 was about 12%, and in March 2022 it was already only 3%. It is worthwhile in further stages, after stabilizing the flow process and the use of electronic documents in the analyzed supply chain, to investigate whether there is a correlation between electronic communication and on-time delivery.

By far the key indicator from the perspective of the recipient's benefit from receiving electronic messages advising delivery is the rightfulness of acceptance of delivery. Admission efficiency has improved due to a 44% reduction in delivery acceptance lead time per supplier. This is very concrete and also the biggest benefit of implementing the DESADV message from the recipient's perspective. DESADV message containing full information on the structure of the delivery, enables its automatic acceptance (scanning of logistics labels from the delivery, concerning DESADV, automatic generation of PZs regarding DESADV), without the need to manually enter data into the system.

It should be stated that a significant reduction in the time of acceptance of delivery on the part of the recipient, can also positively affect the total time of the driver's stay at the recipient, which in turn can be a significant benefit for the logistics operator. This benefit, unfortunately, could not be fully dimensioned, due to the lack of full-time records of the driver's stay at the recipient. This is because several different activities and actions are carried out in the delivery process, not all of which are directly linked to the use of EDI communications.

The indicator to be analyzed in terms of the supply chain (comparing the data of different entities) is the rate of use of EDI documents in the avowal of deliveries. The discrepancies in the data on this indicator reported by the Manufacturer and the Retailer are shown in Figure 3.

Figure 3. Analysis of the rate of use of EDI documents in the dispatch advice - supply chain approach



Source: Lukasiewicz-PIT research

A potential reason for these discrepancies may be the act that the Manufacturer may have provided data on all DESADV messages sent, while the Retailer may have provided data on DESADVs that, once stored in the IT system, had no discrepancies in terms of the message content (e.g., in terms of the Retailer's internal data) and thus enabled automatic acceptance of the delivery.

As a summary of the study of the benefits of the pilot implementation, it should be stated that it is necessary to conduct complementary studies at the logistics operator, as well as to obtain data from all companies from later periods after the pilot implementation.

Regardless of the suggestion to supplement the indicator analysis with data from a longer period after the implementation, and to complete the data by the Logistics Operator, to obtain complete information in terms of the supply chain, it is worth noting that the conducted implementation of the DESADV message, and the indication of a legitimate rationale for the implementation of the expanded RECADV, indicates several benefits of using a complete Order to Cash (O2C) solution in the supply chain, such as:

- Reduction in the number of incorrect deliveries,
- faster order processing by automating the ordering process and being able to start the delivery process quickly,
- faster ability to respond and inform customers when suppliers cannot deliver the products ordered,
- efficient monitoring of inventory levels helps suppliers know exactly when an order will be delivered,
- streamlining the order forecasting process and increasing product availability,
- efficient unloading planning, by reducing delivery queues,

- improved accounting and billing processes, due to the ability to track and store all communications exchanged with suppliers.

5. CONCLUSION

Digitization of the supply chain is a highly topical issue both in terms of business practice and ongoing research work. Identification of the benefits of supply chain digitization solutions is at an early stage and the conducted research should be considered a pilot study, subject to the risk of error. Nevertheless, the analysis of benefits carried out in accordance with the adopted methodology allows for generalizing the following conclusions:

- The pilot implementation of the DESADV message carried out reduced delivery handling costs on the recipient side by 38%,
- Delivery acceptance efficiency on the recipient's side has improved due to a 44% reduction in delivery acceptance lead time on a single supplier (Manufacturer),
- For 98% of deliveries, there is the potential to significantly improve the process of billing for deliveries on the Producer side, by way of automatic issuance of an FV about the RECADV sent by the recipient. This means not only a streamlining of the FV generation process but also a positive impact on cash flow related to delivery payments.
- Due to the significant reduction in the warehouse-level lead time, as a result of the realization of receptions about DESAV, there is a high potential to reduce the total time of the driver's stay at the consignee's premises, in the process of making deliveries. Due to the lack of complete data, this potential could not be measured.
- The indicated conclusions about the benefits of implementing electronic DESADV and RECADV messages, in the main, show a measurable benefit from the perspective of the retail network. However, it should be borne in mind that the measurements are based on data obtained shortly after the implementation, and thus may be subject to some risk of error, related, for example, to the inconsistency of source data at the level of individual partners or the different way in which master data is recorded in the systems of individual companies. It is expected that in the further period after the implementation, the value of the benefits of the implementation may increase and it will be possible to measure more indicators (e.g., as a result of improving the process of generating data on the time of the driver's stay at the recipient's premises).

To confirm the identified benefits and expand their measurement, re-measurement and re-collection of data should be carried out 60 and 90 days after

implementation (stabilizing the EDI process on each side). It is also suggested that further research work be carried out in the analyzed supply chain to expand the content of the RECADV message so that a full record of any delivery discrepancies can be made.

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