Electronic Communication in The Digitization of Logistics

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Abstract:

Purpose: The digitization of logistics processes depends on their integration meant as the connection of digitized business processes of the supply chain into a chain of electronically supported processes. A key aspect of integration is the automated transfer of data between integrated processes. The business processes of participants in supply chains vary in their degree of readiness for digitization.

Design/Methodology/Approach: The author has carried out research of the features of three relatively new technologies used for exchange of electronic data. The reference for the analysis of these possibilities was the list of problems in digitization of business processes defined by the author. Based on his professional experience and on the basis of updated knowledge published by research centers, the author identified eleven main problems that hinder logistics processes digitization. The problems were of a structural nature, related to the components of the digital environment surrounding the enterprise. The study of the properties of these technologies for digital data exchange was performed as a comparative, theoretical test of their ability to support digitization. The author in search of a remedy for the identified problems of digitization, assumed as his goal the search for support tools in the elimination of structural digitization obstacles within the enterprise.

Findings: As a result of study, description of specific features of each technology analyzed was presented in the form of explanation, how specific technical features fit to solve technical limitations of the company in the logistics digitization process.

Practical implications: The efficiency of information flow in supply chains follows the traditional chain principle, i.e. it is determined by the effectiveness of their weakest link. Therefore, the author in this article made an attempt to assess the suitability of some currently available techniques and communication technologies to the diverse needs of enterprises.

Originality value: In the author's opinion, the weakest link in the supply chain can be helped by giving it a choice of how to receive and process business data in electronic form. The study resulted in recommendations on the use of the technologies presented in the logistics processes digitization.

Keywords: Logistic processes, digitization, integration, EDI, PDF-A3, QR-code, blockchain.

JEL codes: C31, D85, L14, L15, L21, L22, L53, L81, L86, M15, O14, O33.

Paper Type: Research study.

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1. Introduction

The readiness of enterprises to digitize logistics processes means their organizational and technical ability to transformation of these processes from their traditional shape into new one, supported by electronic means. The level of readiness is primarily determined by: the organization of logistics processes, the company's business relations, knowledge and availability of digitization methods and tools and the functionality of the company's internal IT systems.

Thus, it is the result of the influence of many factors of an internal and external nature and this influence usually limits the readiness to digitization. Improving the company' readiness to digitize logistics processes is therefore mainly about eliminating the limiting influence of factors dependent on the company.

The author of the article made an attempt to assess the usefulness of three techniques and communication technologies to support the diverse needs as well as organizational and technical capabilities of enterprises. He focused on the analysis of selected factors limiting the readiness to digitize an enterprise. In the author's opinion, the weakest link in the chain of logistics processes can be strengthened by providing it with a choice of electronic collaboration tools, adapted to its local needs, but also its different constraints.

2. Factors of Enterprise Readiness for The Digitization of Logistics Processes

The environment that enables digital support for the operation of logistics processes consists of several basic components, standing for a structural prerequisites for digitization. From the company' perspective, there are the following components, which are a potential source of barriers influencing digitization implementation problems (Toktaş-Palut, Baylav, Teoman, and Altunbey, 2014; Spoz, 2014; Versendaal and Brinkkemper, 2003):

1. external components:
   - requirements of the logistics processes chain,
   - a system for transmitting electronic documents or data in electronic form between companies in the chain of logistic processes,
   - business communication standards used in the logistic chain.
2. internal components of the enterprise:
   - an internal IT system supporting the management of the company's business processes,
   - other internal specialized IT systems dedicated to logistics processes.

For many years, in research on problems of the implementation of digitization processes, regardless of the place of the study and the composition of the focus group, the main problems remain still the same. They are indicated by the surveyed

entities as, the availability of business external communication services and internal, organizational and technical problems of enterprises (Versendaal and Brinkkemper, 2003; Hernandez-Ortega, 2012; Karjalainen and Kemppainen, 2008). These main problems limiting the implementation of digital solutions make it difficult to achieve a higher-level goal, which is the logistics processes digitization.

From the longer list the problems of digitization of logistics processes identified by the researchers, the author of the article prepared a list of basic problems, which in their consequences cause problems of a more complex nature, depicted in Table 1.

Table 1. *Basic technical and non-technical problems of digitization of logistics processes identified by author*

Problem No	Identified digitization problem description
P1	The software is not adapted to the full support of processes, including cooperation with other enterprises by electronic means, in an automated manner
P2	the conviction about the infrastructural lack of services for the transmission of commercial e-documents or a lack of trust in them
P3	lack of readiness of business partners for e-cooperation
P4	problems with distinguishing partners using electronic exchange of commercial documents from non-using in order to determine the channel and format of sent commercial documents
P5	maintaining the compulsory archiving of electronic documents in the face of the variety of document formats used
P6	costs of acquiring knowledge about a business partner candidate for electronic cooperation (e.g. according to the KYC concept)
P7	concerns about a breach of the trade secret contained in the sent electronic documents
P8	concerns about unauthorized violation of the integrity (content) of electronic documents and actions to the detriment of the parties to the transaction
P9	problems with the availability of up-to-date and reliable basic data about products - concerns business partners processing electronic document data
P10	problems with the availability of up-to-date and reliable basic data about products - concerns consumers
P11	other problems in the digitization of business processes in B2BG and B2C relations

Source: *Own study.*

The list presented above begins with the problems of a structural nature described in points 1-3. They are causing further problems, listed in points 4 to 10, related to various aspects of digital collaboration. The result of a business nature is the difficulty of digitizing business processes, indicated in point 11.

While the set of identified digitization problem is presented in a plain list, it does not deliver the knowledge about possible interactions between them. The majority of

identified problems does not exist in separation from the influence of other ones, as well as these other problems may influence other ones mutually.

The mutual influences between identified problems are not always balanced i.e., one problem may strongly affect the second one, while this last one have a little or even none influence on the first one.

For the purpose of recognition of mutual interactions between the problems enlisted in Table 1, the author used the method for supporting the analysis of artefacts coincidence of complex nature, known as the methodology of network thinking. This methodology allows to examine the mutual impact of factors (problems) and find the relation between them, so that in result the influence of every factor on all another factors as well as their backward influence on the first one are identified.

The list of problems identified by the author (Table 1) stands for starting point of their interrelation examination. This list is a foundation of the impact matrix depicted in Table 2. Every relation between given two problems (P1 - P11) is analyzed and the strenght of the influence is assessed by use of numbers from the scale listed below:

0 – no impact
1 – low impact
2 – high impact
3 – very high impact

The final result of the search for the mutual influence between the artefacts from Table 1 is depicted in the Table 2.

Table 2. *The digitization problems and their mutual influence identified - impact matrix*

Factor description	Factor No	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	Total Pn
The software is not adapted to the full support of processes, including cooperation with other enterprises by electronic means, in an automated manner	**P1**	X	0	0	0	3	0	1	1	3	3	3	**14**
the conviction about the infrastructural lack of services for the transmission of commercial e-documents or a lack of trust in them	**P2**	2	X	1	2	0	1	2	2	1	1	1	**13**
lack of readiness of business partners for e-cooperation	**P3**	1	0	X	2	3	3	2	0	3	3	3	**20**
problems with distinguishing partners using electronic exchange of commercial documents from non-using in	**P4**	1	0	0	X	2	1	3	2	0	0	0	**9**

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order to determine the channel and format of sent commercial documents												
maintaining the compulsory archiving of electronic documents in the face of the variety of document formats used	**P5**	0	2	0	0	X	1	0	0	0	0	0	**3**
costs of acquiring knowledge about a business partner candidate for electronic cooperation (e.g. according to the KYC concept)	**P6**	0	0	0	3	0	X	1	2	0	0	0	**6**
concerns about a breach of the trade secret contained in the sent electronic documents	**P7**	1	2	0	0	0	0	X	0	1	1	0	**5**
concerns about unauthorized violation of the integrity (content) of electronic documents and actions to the detriment of the parties to the transaction	**P8**	1	2	2	0	2	0	3	X	1	1	2	**14**
problems with the availability of up-to-date and reliable basic data about products - concerns business partners processing electronic document data	**P9**	0	0	0	0	0	3	0	0	X	0	1	**4**
problems with the availability of up-to-date and reliable basic data about products - concerns consumers	**P10**	0	0	0	0	0	3	0	0	0	X	1	**4**
other problems in the digitization of business processes in B2BG and B2C relations	**P11**	1	1	1	0	0	2	1	1	1	1	X	**9**
Total (P1-P11)		**7**	**7**	**4**	**7**	**10**	**14**	**13**	**8**	**10**	**10**	**11**	X

Source: Own study.

The total values calculated in the impact matrix (Table 2) have been visualized on the impact intensity map depicted in the Fig. 1 below. The impact intensity map was divided to four quarters surrounding the map center identified by highest values of Total Pn and Total (P1 – P11) columns divided by two. This way the map center is indicated by the point of intersection of the horizontal line at value 8 and vertical one at value 12,5.

Each factor is defined now by its identifier (P1 - P11) and its numbers calculated in the impact matrix, e.g. the factor: 'The software is not adapted to the full support of processes, including cooperation with other enterprises by electronic means, in an automated manner' has the Id: P1 and intensity values (14, 7), where the first

number (14) reflects the influence of the factor P1 on other factors (P2 - P11), the second one (7) – influence of other factors on the factor P1.

Figure 1. *The digitization problems and their mutual influence classification*
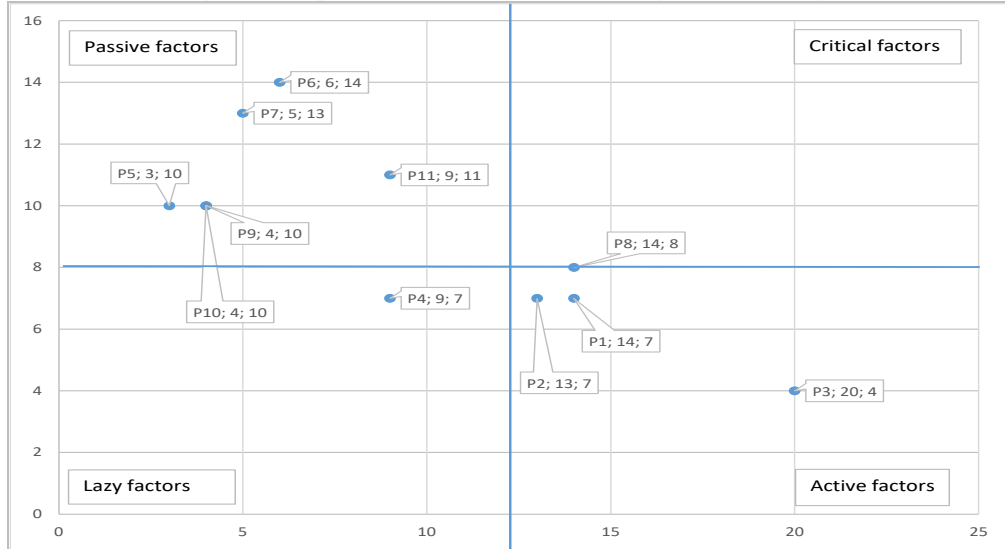
Source: Own study.

The most important factors of influence are those which have a very high level of influence on other factors considered, while those other factors have low influence on the first ones. They are labeled as "Active factors" and placed in the bottom-right quarter of the Figure 1.

The "Active factors" identified are:

P3: 'lack of readiness of business partners for e-cooperation'; influence numbers: (20;4)
P1: 'the software is not adapted to the full support of processes, including cooperation with other enterprises by electronic means, in an automated manner'; influence numbers: (14;7)
P2: 'the conviction about the infrastructural lack of services for the transmission of commercial e-documents or a lack of trust in them'; influence numbers: (13;7)

From the perspective of digitization of logistics, these "Active factors" represent the toughest barriers limiting implementation and represent the weakest links in the supply chains integration. They are also recognized as the factors which are the foundation of the theory of value chain governance (Gereffi, Humphrey, and Sturgeon, 2005).

In search of a remedy for presented problems of digitization, the author assumed as his goal the search for tools supporting the elimination of structural digitization

obstacles within the enterprise e.g., P1 above. In a such approach, infrastructural obstacles outside the enterprise are external parameters over which the enterprise has no influence (P1 and P2 above). The overriding requirement adopted by the author in the search for the aforementioned supporting tools was the assumption about the perception of business processes as the subject of activities enabling their gradual automation. The additional guideline was the claim that the weakest link in the chain of logistics processes can be helped by giving it a choice of electronic cooperation method to support the digitization of these processes. In result, the possibility of overcome of both internal (P1) and external (P2 and P3) barriers are subject of author's consideration.

The author analyzed the features of three technical solutions that have been appeared on the market in the last few years and whose purpose is to support the implementation of selected communication methods. These solutions have been analyzed by the author from the point of view of their potential as the tools in the digitization of logistics processes, especially in the context of P1, P2 and P3 factors described above.

The subject of the analysis were the following communication technologies expected to meet specific needs in the context of digitization:

1. exchange of electronic commercial documents in a hybrid format based on the PDF/A-3 standard,
2. sharing electronic data of commercial documents in the QR code,
3. exchange of commercial documents in Blockchain technology.

3. Exchange of Electronic Business Documents in a Hybrid Format Based on The PDF/A-3 Standard

The main reason for the interest in use of documents in the PDF/A-3 standard is its double (hybrid) information structure. PDF/A-3 format based on the ISO 32000-1 standard offers support for embedded files. It means, that "Smart documents" use PDF/A3 as container format. In addition to the main document sent, files of any format can be included in the attachments, e.g. from word processing or XML files." (Kaiser, Licker, and Mayer, 2016).

The main features of e-documents in the hybrid format which may help to solve digitation problems are as follows (relevant Table 1 problem number in brackets):

- by providing both a human-readable (PDF) and machine-readable (XML) information layers in a single file sent to all its recipients, the e-document' issuer is not in concern of the question, which partners are able or not to receive e-documents in a structured format. Recipients whose business IT systems are not able to receive e-documents automatically, may still pick up them by other tools eg. email, collaborative platforms etc., (see Table 1 - P1).

- The visual layer of PDF/A-3 format is accessible practically for every recipient. The structured text layer may be used by more technically advanced recipients, using their IT systems able to automatically receiveand proces the document in PDF/A-3 format (see Table 1 - P3).
- The e-documents in the PDF/A-3 format may consist of a both visual and a machine readable representation, in result - it is up to the document' recipient to choose the layer it is able to proces (see Table 1 – P4).
- The PDF-A technology ensures continous documents readability based on ISO 32000-1 standards features, archiving them for every period required despite development of technology (see Table 1 P5).
- Thanks to the twofold data representation, next to all companies in B2B, even consumers can be recipients of the hybrid documents in B2C relations (see Table 1 - P11).

This way the PDF/A-3 format enables a business document issuance, reception and processing, so that such support for logistics processes and their cost reduction may improve the efficiency of the whole chain of logistic processes.

4. Sharing Electronic Data of Commercial Documents as the Content of QR Code

The main purpose of using QR codes is to allow to present the document' content in a structured way and be processed by IT systems (Giner, Cetina, Lacuesta and Palacios, 2012).

The main features of use of data encoded in the QR code, expected to support digitization of the logistic processes are as follows (relevant Table 1 problem number in brackets):

1. the data read from the code can be transmitted to the system to which the scanner is connected to. It allows for ommiting the regular system' API in reading the data and putting them directly into the system' database. The coded data can be scanned and recognized from the paper document too (see Table 1 - P1).
2. the second purpose of QR code use is to receive the *Quick Response (QR)*. This feature allows for immediate access to the document' data coded in the QR code placed inside this document (see Table 1 - P3).
3. The quick response concept is solving the problem of availability of reliable and current product master data for business partners processing electronic document' content. The QR functionality enables companies for automated access to the product' information when the code is used to carry this information in the standalone or mobile reception conditions (see Table 1 - P9).
4. It also resolves the problem met by consumers when they are looking for the product 'from the shelve' information. Quick response (QR) functionality enables consumers for immediate access to the product' data coded in the QR code placed on product' label (see Table 1 - P10).

5. The business results of using the QR code may be observed as increased efficiency of logistics processes eg. in a parcels delivery, boarding to the plane, recognizing the person' or object' identity etc. This technology may be used in conjuction to other technologies to support more complicated processes (see Table 1 - P11).

5. Exchange of Business Documents in the Blockchain Technology

Blockchain technology represents the concept of the data structure, rules of their processing and interpretation allowing for the specific data configuration as the events interpretation (García-Bañuelos, Ponomarev, Dumas, and Weber, 2016). It is offering some new features which may allow for new approach to many aspects of digital economy (Cunha, Soja, and Themistocleous, 2021).

Basic technical features of the technology which make it attractive for business processes are as follows (Sarmah, 2018):

1. every data block represents an 'event',
2. every data block has its own hash of the block and the hash of the previous bloc (hash stands for the cryptographic numerical value calculated for each block),
3. every data block has its own 'proof of work' - a mechanism that enables the creation of new blocks (eg. in bitcoins case). This mechanism makes it very hard to manipulate the blocks since it is necessary to recalculate the proof of work in a given block and all next (following) blocks,
4. every node of the blockchain channel of connections got a full copy of the blockchain and can use this to verify any new events,
5. blockchains are immutable and kept distributed (distributed ledger) - every new block is sent to each node of the network, where it is verified to make sure that it hasn't been tampered with. Tampered block are rejected by other nodes in the network then,
6. the blockchain may use the smart contracts – a simple programs that are stored on the blockchain and can be used to automatically execute when certain conditions happened. The smart contracts are also immutable (Rahman, Liu, and Kagal, 2020; Huang, Bian, and Li, 2019),
7. tampering the blockchain with smart contracts becomes almost impossible.

Thanks to these features, the Blockchain technology ensures support for digitization of the logistic processes by:

- digitization of business processes in B2B relations without the direct participation of the IT system (ERP) possible, thanks to the structure and principles of data processing in Blockchain technology. Blockchain technology enables a new way of implementing various business processes, e.g., concluding and settling consumer contracts by banks, insurance, utilities delivery settlements, including B2C relations. It can support the implementation of logistics processes by

binding the records of all events in the supply chain into one blockchain set, incl. e-ordering, shipment e-documents, e-invoicing, e-payment (Cunha, Melo, and Sebastião, 2021) (see Table 1 - P1),
- elimination of the lack of trust in the third party intermediating in the exchange of e-documents (Themistocleous, Christodoulou, Iosif, Louca, and Tseas, D. 2020) (see Table 1 - P2),
- availability of verifiable history of all transactions registered in the blockchain (see Table 1 - P5),
- building the transaction partners trust despite the lack of full knowledge about them thanks to the mechanisms described above (see Table 1 - P6),
- built-in data access protection mechanisms - the user can only view his / her transactions (see Table 1 - P7),
- anti-counterfeit detection / prevention rules (Chen and Pendleton, 2020) (see Table 1 - P8),
- simultaneous updating of business data in all IT systems of partners in B2B in the blockchain network thanks to distributed (and thus shared) data blocks from the data owner (see Table 1 - P9),
- consumer' access to complete and up-to-date product information obtained from the manufacturers' products master data resources by scanning the QR code on the product label (see Table 1 - P10),
- reduction of the complications of handling commercial transactions resulting from the sequential and time-consuming series of subsequent activities in business processes. It allows for shortening the cycles of: preparation, implementation, execution and settlement of contracts thanks to records updating data on the entire transaction cycle and the possibility of automatic response to events (smart contracts) (see Table 1 - P11).

As said before, the Blockchain technology provides a means of automating trusted operations (Balazs, 2021; Dhar and Bose, 2020), important for business functions which will also benefit from the speed and efficiency of blockchain technology. The information gathered and transmitted along the supply chain in the Blockchain technology stores every detail of every event and whole transaction at every level.

6. Conclusion

The review of three technologies conducted in context of identified digitization problems unveiled how their specific technical features may be used to solve technical limitations of the companies in the logistics digitization process. Table no 3 presents the symbolic results of review, indicating each technology' ability to support a given digitization problem solution.

Thus it stands for general recommendations of the use of them in a specific company' situations. The detailed description of specific features and the way they can support the solution is presented in the parts of article dedicated to every analyzed technologies.

Table 3. *The ability of the technologies analyzed to improve the level of digitization of logistics processes*

Factor No	Identified digitization problems	e-documents in hybrid format	QR code as data layer	Blockchain as the data layer
P1	The software is not adapted to the full support of processes, including cooperation with other enterprises by electronic means, in an automated manner	+	+	+
P2	the conviction about the infrastructural lack of services for the transmission of commercial e-documents or a lack of trust in them			+
P3	lack of readiness of business partners for e-cooperation	+	+	
P4	problems with distinguishing partners using electronic exchange of commercial documents from non-using in order to determine the channel and format of sent commercial documents	+		
P5	maintaining the compulsory archiving of electronic documents in the face of the variety of document formats used	+		+
P6	costs of acquiring knowledge about a business partner candidate for electronic cooperation (e.g. according to the KYC concept)			+
P7	concerns about a breach of the trade secret contained in the sent electronic documents			+
P8	concerns about unauthorized violation of the integrity (content) of electronic documents and actions to the detriment of the parties to the transaction			+
P9	problems with the availability of up-to-date and reliable basic data about products - concerns business partners processing electronic document data		+	+
P10	problems with the availability of up-to-date and reliable basic data about products - concerns consumers		+	+
P11	other problems in the digitization of business processes in B2BG and B2C relations	+	+	+

Source: *Own study.*

The technologies analyzed in the article were developed independently of each other, each of them was created on the basis of previously existing technologies, operating in separate areas of application. The purpose of studying these technologies was not to obtain a ranking of their technical capabilities, but the possibility of using them in the digitization of logistics processes.

The properties of these technologies have been verified in terms of the possibility of supporting the removal or reduction of the digitization problems described in Table 1.

The obtained results of the analysis make it possible to find recommendations for use of these technologies, which, under certain conditions of a company, can improve its readiness to digitize the logistics processes, as described above.

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