Original Paper

Digitization of Macro-Logistics Systems in Ukraine

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Abstract

This article delves into the multifaceted realm of digitizing macrologistical systems, scrutinizing their nature, influencing factors, and emerging trends. It intricately explores how the integration of digital technologies empowers transport enterprises to deliver superior logistics services while concurrently curtailing costs. A comparative analysis meticulously dissects various facets of the macrologistical system, elucidating the interplay and correlation of its elements within the realms of commodity-money and contractual relationships. The study accentuates the pivotal role of the macro-logistics system in supply chain management.

In scrutinizing Ukraine's Logistics Performance Index scores vis-à-vis EU countries, the authors attribute the disparity to the enduring conflict. A notable European logistics market trend is identified: a surge in digitization investments by individual companies and the establishment of cohesive online platforms. The paper advocates for the integration of automation in transport logistics, particularly in the backdrop of a wartime economy.

European standards for a contemporary transport management system are analyzed, culminating in the selection of the CargoClix logistics platform. The article expounds on the platform's merits in adeptly digitizing the operations of transport and logistics enterprises, offering real-time tracking crucial for prompt responses amid wartime exigencies.

The article concludes by substantiating findings with pertinent diagrams and tables. In essence, the digitization of macrologistical systems entails a holistic amalgamation of digital technologies, data analytics, and decision-making solutions for information management in logistics and supply chain operations. This transformative journey, leveraging technologies such as the Internet of Things, unmanned technologies, identification technologies, blockchain, big data, robotic systems, artificial

intelligence, and neural networks, aspires to amplify efficiency, visibility, and coordination throughout the supply chain. This paradigm shift is pivotal for evaluating the efficacy of transport and logistics companies, determining their competitive stance in today's market. Future research trajectories encompass formulating strategies for national companies operating in the domestic logistics market, identifying and implementing key competitive advantages, and devising measures and tools to ensure efficiency during wartime.

Keywords

macro-logistics systems, transport, costs, digitalization

1. Introduction into Macro-Logistics Systems

In the conditions of Ukraine's wartime economy, fundamental changes have occurred in the logistics system for international communication and freight transportation. Currently, the primary burden in freight transportation falls on road transport. This has led to frequent traffic jams at Ukraine's borders, with drivers forced to wait for hours or even days in queues at border checkpoints. The situation is further exacerbated by occasional border blockades initiated by Polish carriers. According to official data, the flow of freight transport across the Polish-Ukrainian border decreased tenfold in the autumn of 2023. The blockade adversely affects both Ukrainian and EU businesses. Transportation delays at the border result in disrupted supply contracts and a sharp increase in costs. Therefore, the issue of cost reduction becomes increasingly relevant, allowing all participants in the macro-logistics system – manufacturing enterprises, transportation companies, and warehouse intermediaries – to survive. Reducing costs will allow the enterprise providing transport services not only to lose existing customers, but also to attract new ones, which will ultimately ensure the survival of the enterprise itself. Providing high-quality logistics services at lower costs is possible due to the introduction of digital technologies. As experience shows, the economic effect of digital transformation in logistics is quite tangible.

Therefore, the study of problems and prospects of digitalization of logistics is relevant both from the point of view of economic theory and business practice. Studies of various aspects of macro-logistics systems are presented in the publications of both domestic and foreign scholars. In particular, S. Bestuzheva and S. Ohienko investigate the nature and features of the macrologistic system (Bestuzheva, Ohienko, 2023, p. 16).

The work of L.Gurch is devoted to the problems of designing logistic transport systems. Special attention is focused on the fact that when designing a macro-logistics system, it is necessary to ensure the mutual agreement of the interests of each participant, regardless of the role in the created system, as well as to maintain a balance between costs and the quality of services (Gurch, 2022, p. 143).

O. Garafonova, D. Kozlovskyi, V. Sharov, I. Dvornyk in their work analyze various aspects of the functioning of international logistics systems, emphasize the need for their rationalization through cost optimization (Garafonova, Kozlovskyi, & Sharov, 2022).

The article of J. Domagała is devoted to the representing of the elements of the macro-logistics system (transport networks, systems of product distribution, infrastructure connected with the flow of information and systems for the management and treatment of waste) as factors in the development of the Polish economy (Domagała, 2020, p. 35). She underlines the importance of macrologistics on today's market results from the view point of trends appearing in modern action strategies oriented at the management of entire supply chains and the growing role of time.

Jan H. Havenga conducted a review of macrologistics, followed by a discussion on macrologistics instrumentation, which is twofold: a freight-flow model and a related logistics costs model (Havenga, 2018). V. Humeniuk and other authors analyze the impact of the global pandemic on the functioning of the business sector of the countries of the European Union (Humeniuk, Umantsiv, Dligach, Ivanova, & Umantsiv, 2021, p. 330).

O. Garafonova, D. Kozlovskyi, V. Sharov, I. Dvornyk analyse the macrologistic system as a large material flow management system that includes enterprises and industrial organizations, intermediary, trade and transport organizations of various departments. Interrelationships of elements of the macro-logistics system are built taking into account commodity-monetary and contractual relations. The development of macro-logistics takes place under the influence of the regionalization, which is manifested both at the level of individual countries and on an international scale. The formation of numerous integration links among the regions of the country, as well as with foreign countries, necessitates the material and technical management of numerous interregional material, as well as accompanying financial and informational flows (Garafonova, Kozlovskyi, & Sharov, 2022).

According to L. Gurch, the macro-logistics system is a highly integrated infrastructure of the economy of a region, country or group of countries (Gurch, 2022, p. 143). S. Bestuzheva, S. Ohienko define the macro-logistics system as a set of logistic processes within the national economy (Bestuzheva & Ohienko, 2023).

Macro-logistics includes global economic processes studied on the level of the whole country, industry, region, or international organization. Macro-logistics systems consist of the following elements:

1) transport and freight networks – road network, rail network, auxiliary infrastructure, etc.;

2) product distribution systems – logistics centres, container terminals, handling ports, etc.;

3) infrastructure connected with the flow of information accompanying physical flows in supply chains – IT networks and databases concerning all areas connected with logistics in various sectors and trades;

4) systems for the management and treatment of waste – installations for storage, recovery and neutralization and/or incineration of waste; solutions allowing technological mergers of enterprises, etc. (Domagała, 2020, p. 40).

So, in general, the macrologistic system can be defined as an integrated system of managing material, financial and information flows, the participants of which are not restricted in the territorial location and are represented by the enterprises, institutions and organizations of various spheres of the economy and forms of ownership.

According to the World Bank data on 2023 Logistics Performance Index (LPI) Ukraine has Grouped Rank 79 with Score 2.7:

−   Customs Score – 2.4;

−   Infrastructure Score – 2.4;

−   International Shipments Score – 2.8;

−   Logistics Competence and Quality Score – 2.6;

−   Timeliness Score – 3.1 (Logistics Performance Index, 2023).

The LPI is an interactive benchmarking tool created to help countries identify the challenges and opportunities they face in their performance on trade logistics and what they can do to improve their performance. Analysis of 2023 LPI shows that Ukraine has lower scores comparing with countries of EU in which the score is in the range from 3.2 for Romania to 4.2 for Finland.

2. Digitization of Macro-Logistics Systems

It should be mentioned that one of the leading tendencies in European logistics is steady investment in digitalizing the organization of companies (Sichkarenko, 2019). The digitization of macro-logistics systems refers to the process of incorporating digital technologies, data analytics, and information management solutions into the broader logistics and supply chain operations on a large scale. Digital technologies used in logistics include: Internet of Things, self-driving cars, identification technologies, blockchain, big data, paperless technologies, drones (unmanned aerial vehicles), robotic systems, artificial intelligence and neural networks. This transformation aims to enhance efficiency, visibility, and coordination across various elements of the supply chain, including production, transportation, and distribution (Table 1).

Table 1. Key Aspects of the Digitization of Macro-Logistics Systems

№	Key aspects	Characteristic
1	Automation	The use of automated systems and robotics to streamline and optimize tasks traditionally performed by humans, such as order fulfillment, inventory management, and material handling
2	Data Analytics	Leveraging advanced analytics and big data techniques to gather, analyze, and derive insights from vast amounts of data generated throughout the supply chain. This enables informed decision-making, demand forecasting, and performance optimization
3	IoT Integration	Incorporating the Internet of Things (IoT) devices and sensors into physical assets, allowing real-time monitoring and tracking of goods, equipment, and vehicles. This enhances visibility and provides valuable data for improving overall efficiency

4	Cloud Computing	Utilizing cloud-based platforms for storing, accessing, and sharing data. Cloud computing facilitates collaboration among various stakeholders in the supply chain and supports scalable and flexible operations
5	Blockchain Technology	Implementing blockchain for secure and transparent record-keeping. Blockchain can enhance traceability, reduce fraud, and establish trust among participants in the supply chain.
6	Digital Twins	Creating digital replicas of physical assets, processes, or systems. This allows for simulation, analysis, and optimization of logistics processes in a virtual environment before implementation in the physical world
7	Artificial Intelligence (AI)	Applying AI algorithms to improve decision-making, predictive analytics, and anomaly detection within the logistics system. AI contributes to optimizing routes, managing inventory, and predicting maintenance needs
8	E-commerce Integration	Adapting logistics systems to meet the challenges posed by the rise of e-commerce, including last-mile delivery optimization, order fulfillment speed, and customer experience enhancement

Source: developed by the authors.

Thus, the port of Rotterdam is being transformed into a single digital space with the help of Internet of Things technology. In the port, "digital dolphins" are installed - intelligent sensors that support traffic flows, including cargo transportation. "Dolphins" are capable of self-learning, their basis is neural networks.

The introduction of robotic systems is justified in road and rail transport for routine work at maintenance stations. Automation of transport logistics includes the use of vehicle management assistance systems and Transport Management System (TMS) software. Automated driver assistance systems for driving the truck are represented by adaptive cruise control and the function of driving assistance within the lane. Full automation also includes environmental monitoring and detection of special driving conditions. Modern TMS meet the following requirements:

- form realistic routes that can be followed by drivers and allow to change routes in real time according to changes in road conditions;

- display the time of vehicle arrival at each destination;

- allow you to automatically monitor drivers on routes (truck location, engine performance indicators, truck mileage, etc.);

- calculate the efficiency of the vehicle fleet that will be used in the transportation process (when forming the order, indicate the size of the order, the volume and weight characteristics of the cargo, the carrying capacity and the volume of the truck body that will be submitted for loading) (Osetskyi, Klymenko, Lozova, & Umantsiv, 2023).

Blockchain technologies are used to document logistics operations in transport, conclude contracts and

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execute multilateral agreements (for example, in multimodal transportation, interaction between the owner of the cargo and the carrier and forwarder at all stages of the transportation process is ensured), tracking of cargo and registration of its quality (in particular, for food products delivery conditions (humidity, temperature) are registered, and there is also the possibility of their adjustment during transportation), real-time display of goods shipment operations, financial support of the transportation process.

Drones are still used for monitoring sections of highways and railway tracks, aerial photography, constant monitoring and escorting of cargo. However, in the future, drones can become a new mode of transport for carriage of passengers and cargo (Sichkarenko, 2019).

3. Optimization of Logistics Processes Using Cargoclix Platform

Let's consider how the introduction of digital logistics platform allows us to optimize time and costs. As soon as drivers arrive at the facility, they have some specific time to unload or reload their cargo. Downtime caused by uncertain work schedules results in paying fines, it also requires additional time for dispute resolution. In order to avoid or at least reduce the number of such issues at the warehouse time slot management systems can be used both by carriers and shippers (GoRamp, 2022).

Cargoclix is a logistics platform that creates products aimed to optimize logistics processes. It produces software for transport and logistics and has been consistently focusing on the latest technologies and innovative concepts since 1998. The products are modular and can be used individually or in combination. The products are available to all users in the cloud online (Cargoclix, 2022).

One of the most successful product of the platform is Cargoclix SLOT. It is the time slot management system that optimizes processes and personnel deployment at the ramp and prevents waiting times and workload peaks at loading and unloading points (SLOT, Official website of Cargoclix, 2022).

The advantages of usage of Cargoclix SLOT are identified in the Figure 1.
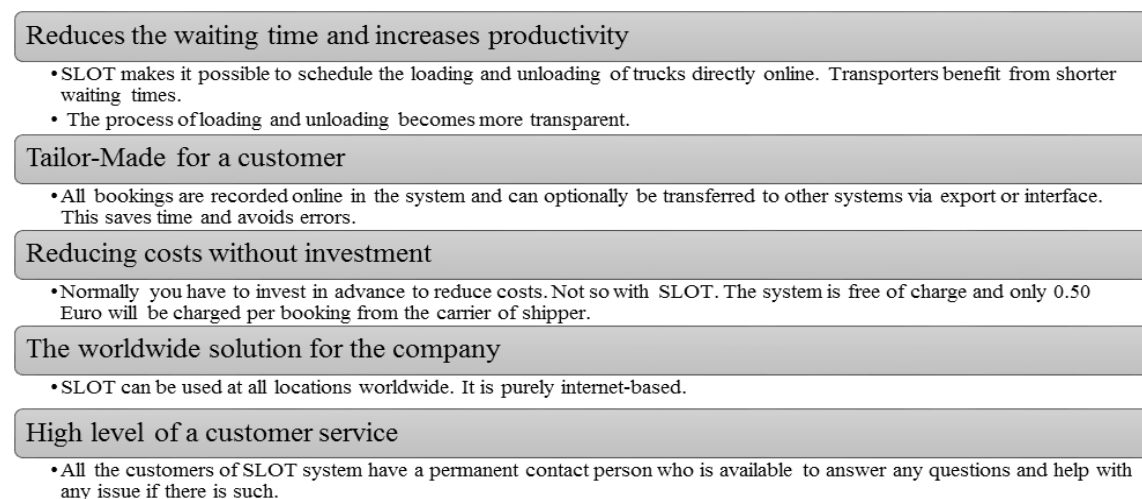
Reduces the waiting time and increases productivity
- SLOT makes it possible to schedule the loading and unloading of trucks directly online. Transporters benefit from shorter waiting times.
- The process of loading and unloading becomes more transparent.

Tailor-Made for a customer
- All bookings are recorded online in the system and can optionally be transferred to other systems via export or interface. This saves time and avoids errors.

Reducing costs without investment
- Normally you have to invest in advance to reduce costs. Not so with SLOT. The system is free of charge and only 0.50 Euro will be charged per booking from the carrier of shipper.

The worldwide solution for the company
- SLOT can be used at all locations worldwide. It is purely internet-based.

High level of a customer service
- All the customers of SLOT system have a permanent contact person who is available to answer any questions and help with any issue if there is such.

Figure 1. Advantages of Cargoclix SLOT

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Source: developed by the authors based on information (SLOT, Official website of Cargoclix, 2022)

In the Figure 2 interface of the system Cargoclix SLOT is depicted. Considering interface of the system, it is possible to state that is simple and should be easily perceived by the employees of Trans-Logistics. Dark gray fields mean that the ramp cannot be booked (it is closed); diagonal gray striped fields mean that rapms are booked by other customers; white fields mean that the ramp is available to be booked.
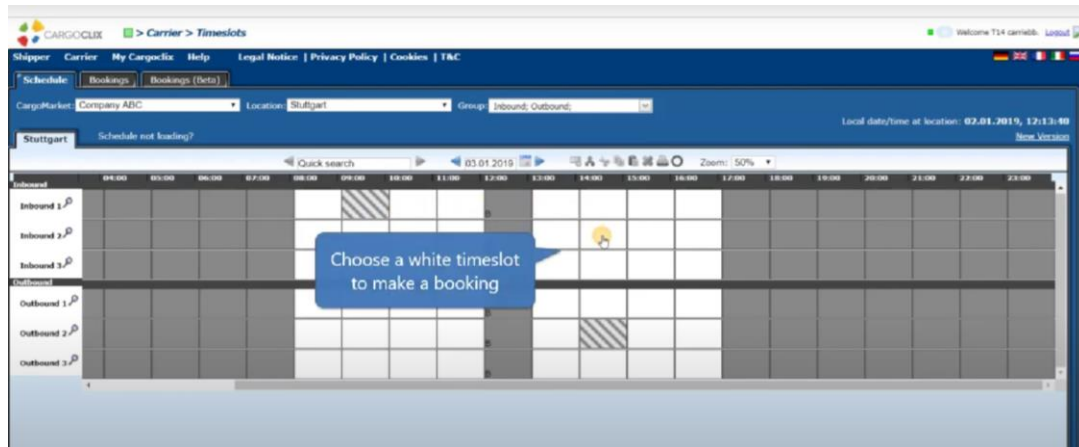

Figure 2. Interface of the System Cargoclix SLOT

Source: developed by the authors based on information (Manual for the use of time slot management system "Cargoclix" at Marquardt Logistic GMBH, 2022).

After choosing the ramp and time you need to enter all the load and truck details. They include:

1) Order number

2) Name of the carrier

3) Mobile phone

4) Vehicle type

5) Truck plate

6) Number of pallets

7) Other notes

After you enter all the above mentioned details a PDF file is created that the carrier can print out. The file contains all data of the booking, including the booking ID (Figure 3).

Timeslot Booking Confirmation

CARGOCLIX

Carrier	Marquardt Test GmbH
User	Internal Service Provider
Forwarding agency	Example
Vehicle license plate	TEST
Access card no. (select)	please select
Number of reference numbers (select)	1
Reference number	2797619
Charge carrier (select)	Pallets
Number of pallets	15

Cargoclix Booking ID
29509481

Cargomarket Bookings-ID

Comment

Date And Time	14.01.2022 18:40-19:14
CargoMarket	Marquardt Logistik GmbH
Location	Rietheim
Ramp name	Ramp 10
Group	Truck - Outgoing Goods
Description	Ramp 10 is used for the **collection of goods** at Logistics Center Rietheim. At this ramp, **only trucks** can be loaded **by rear loading.**Please **register first at our registration office**. The **access** is located to the **right of ramp 1**

Figure 3. Timeslot Booking Confirmation

Source: developed by the authors based on information (Manual for the use of time slot management system "Cargoclix" at Marquardt Logistic GMBH, 2022).

Cargoclix SLOT also provides truck drivers with real-time information on current restrictions on warehouses and other facilities they are rolling to. This feature was especially useful in the period of rapid spread of COVID-19 for truckers who travel long distances between different regions and countries and may not be aware of all the changes in quarantine restrictions associated with the pandemic. Thus, when the driver arrives at the place of the pick-up or delivery, he is already informed about how to behave and what documents (test results, vaccination certificate, etc.) to provide. That is, the driver knows whether to move from the logistics center from right to left or vice versa, where not to go, where to wear a mask, where to show a certificate, if necessary, and so on. The system also allows you to book the time and place of unloading / loading but not to stand in line.

During hostilities throughout the territory of Ukraine this SLOT's tool can be very useful as well. At the security point, shipper or receiver can require 1-2 forms of government ID in order to check the identity of the driver. This information can be also mentioned in the application to inform the driver in advance. Moreover, a lot of facilities has changed its working hours or work unstable because of the

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military actions. SLOT helps to avoid the situation when the driver arrives at the location but there is no one to load or unload the truck, so it will save a lot of time and money. The necessary information "from each ramp" can be sent in real time with one click to all interested parties.

There is also a lot of other time slot management systems available to use now. All of them are offering approximately the same range of services with slight deviations. The most popular are Time Slot Booking by Transporeon, Cargoclix SLOT, Time Slot Management by SPOT, Alpega TMS, GoRamp. The majority of this systems are free for carriers and paid by the shipper. Price per slot are given in Figure 4.
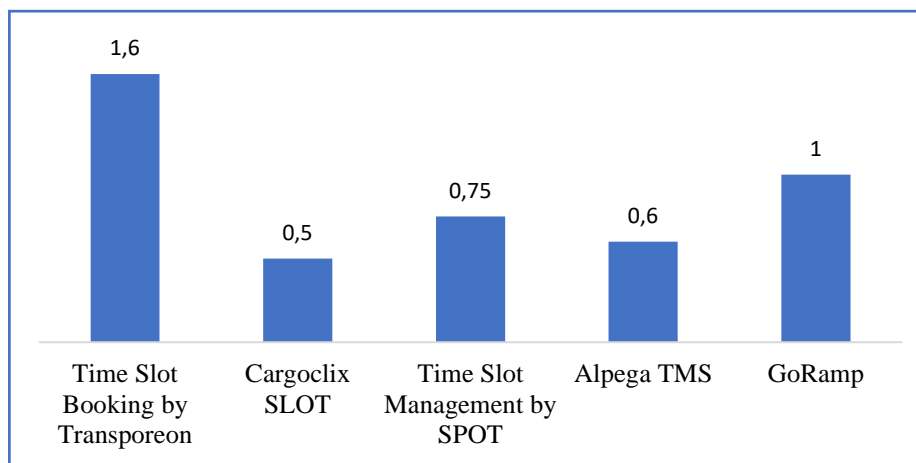

Figure 4. Price of Usage Time Slot Management Systems per Slot Booked, Euro

Source: developed by the authors based on research.

As we can see, Cargoclix SLOT provides one of the lowest rates (0.50 Euro per booking). This charge can be paid either by shipper or by carrier. Cargoclix SLOT is widely used in many European countries and should be useful for Trans-Logistics.

In order to make some conclusions and measure effectiveness of implementation SLOT system we can make analysis of duration of loading or unloading at a time of using and not using of the system. The pickup process usually is longer and more complex, many delays arise at this stage of transportation process. Therefore it is more reasonable to investigate how it can be impacted by the innovation. All the regular operations during the pickup of goods and its duration are represented in Table 2.

Table 2. Duration of the Operations at the Process of Pickup Using Cargoclix SLOT and without It

Operation	Duration of the operation, min	Duration of operation using Cargoclix SLOT, min

The way of the driver to the control room, to receive the documents and instructions where to follow next	2	2
Time needed for the shipper to find the load in the system, check its status and prepare all required paperwork	10	2
Assignment of the loading ramp	1	0
The way of the driver to the truck and entrance to the loading yard	5	5
Waiting for your turn to get loaded	0-90	0
Setting the truck at the loading ramp, preparing ramp capacities (staff, forklift trucks, etc.)	3-18	3
Loading the truck	15-60	15-60
Inspection of the pallets/containers/boxes, comparison of their numbers and seals with the data in the documents	3	3
Departure of the truck from the cargo front and the driver's passage to the control room	5	5
Registration of documents on acceptance of the load	10	10
Total duration	**54-204**	**45-90**

Source: developed by the authors based on research.

As we can see such operations as the way of the driver to the control room, to receive the documents and instructions where to follow next, the way of the driver to the truck and entrance to the loading yard, inspection of the load, its compliance to the documents, departure of the truck from the cargo front and the driver's passage to the control room and registration of documents on acceptance of the load take the same time both in case when you are not using any time slot management application and when you are using Cargoclix SLOT. However, there is a difference in time during other processes.

First of all, time needed for the shipper to find the load in the system, check its status and prepare all required paperwork for the driver is reduced in average by 8 minutes. When reserving a time for loading or unloading the carrier can mention a reference or pickup number for the load they are going to carry. At the shipper's system this information is displayed so if you have booked a timeslot for example for 9 am, the shipper would know that they need to prepare all the paperwork and load upon the truck's arrival, so it will take the minimum amount of time.

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Even in case when the load is not ready for some reason, due to some emergency for example, the driver should not check each 15 minutes on it until the truck could get loaded. Instead, he can get a notification in the application once the load is ready and he can follow to a loading ramp. When using Cargoclix SLOT application the loading ramp is assigned automatically while booking a timeslot so there is no time spent at the facility.

There is an impressive time difference in waiting for your turn to get loaded. If the carrier is using Cargoclix SLOT once the driver has all required documents, he can just roll to the assigned loading ramp. Otherwise, the driver will need to wait until the ramp is available. Certainly, the driver can arrive in the period of time when there is no line and correspondingly no waiting time at this stage. However, if we have pickup or delivery at 8-10 am or any other rush hour, most probably the driver will need to wait for another hour or two, especially if it is large facility with a lot of orders. The same goes for equipment needed to load or unload the truck, such as a forklift, pallet jack, cart, etc. Sometimes the driver needs to wait for it if it is not available at the moment of loading. In the Figure 5 comparison of the Duration of the operations at the process of pickup using Cargoclix SLOT and without it is depicted.
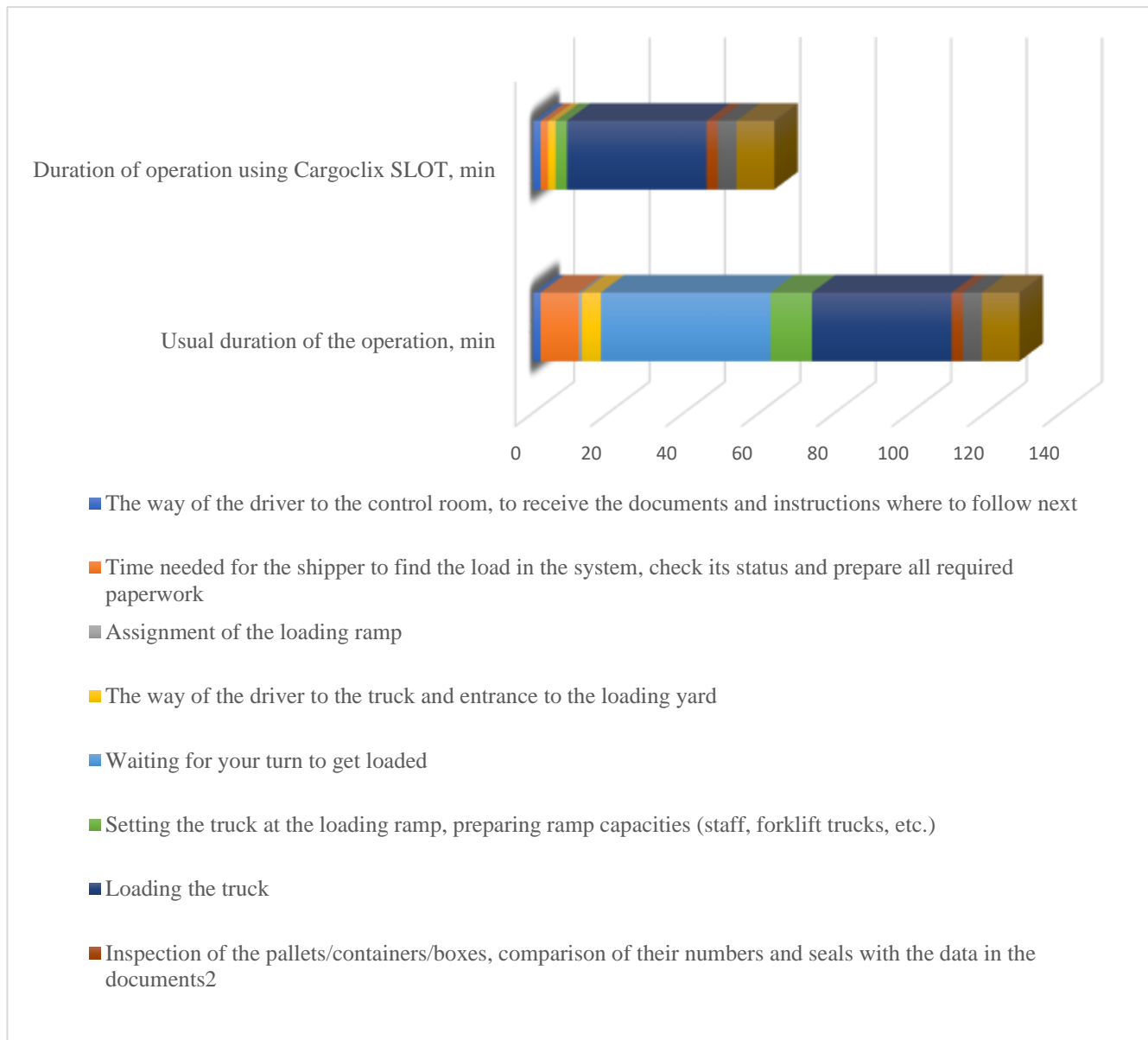
The way of the driver to the control room, to receive the documents and instructions where to follow next

Time needed for the shipper to find the load in the system, check its status and prepare all required paperwork

Assignment of the loading ramp

The way of the driver to the truck and entrance to the loading yard

Waiting for your turn to get loaded

Setting the truck at the loading ramp, preparing ramp capacities (staff, forklift trucks, etc.)

Loading the truck

Inspection of the pallets/containers/boxes, comparison of their numbers and seals with the data in the documents2

Figure 5. Comparison of the Duration of the Operations at the Process of Pickup Using Cargoclix SLOT and without It

Source: developed by the authors based on the Table 2.

When building a graph if there is a range of possible duration of an operation, the average value has been taken. For example in case of waiting for your turn to get loaded, 45 minutes were taken as an average between 0 and 90. Summarizing the above information, we can conclude that if Trans-Logistic integrates time slot management system Cargoclix SLOT, duration of loading and unloading processes would be reduced in average by 46%. Accordingly the company's efficiency will be higher, better customer service would be able to be provided that will definitely lead to increased profit.

4. Conclusions

Analysis of the nature and factors of digitizing macrologistic systems has allowed for a detailed examination and disclosure of new trends and key aspects, determining the impact of digitization on the quality of logistic services and transportation costs. Digitization of macrologistic systems is a process that involves the integration of digital technologies, data analytics, and solutions for managing information in logistics and supply chain operations. These technologies encompass a wide range of tools, such as the Internet of Things, unmanned technologies, blockchain, big data, robotic systems, artificial intelligence, and neural networks.

The interrelation and interaction of various aspects of macrologistic systems in the context of commodity-money and contractual relations have been identified. The reasons leading to the deterioration of Ukraine's rankings in the Logistics Performance Index compared to EU countries have been analyzed.

Special attention is given to the analysis of investments in digitization on the European logistics market. The advantages of integrated online platforms and the implementation of automation in transport logistics are highlighted. Analyzing the pros and cons of different logistic platforms has led to the identification of Cargoclix as a logistic platform.

The authors have analyzed key performance indicators and parameters to determine the effectiveness of implementing the logistic platform, substantiating the importance of digitization for all market participants. The conducted analysis provides a basis for defining digitization as a strategically important direction to ensure the efficiency of transport and logistics companies in times of war and determining their competitive advantages. Thus, the article makes a significant contribution to the study of digitization issues in macrologistics.

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