

Research Article

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THE IMPACT OF DIGITALISATION AND
OPERATIONAL COORDINATION ON
TRANSPORT EFFICIENCY IN INTERMODAL
LOGISTICS

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Background. Modern logistics is impossible without the construction and development of intermodal logistics hubs, the effectiveness of which largely depends on the level of digitalisation and the quality of operational coordination, which are key factors in their competitiveness.

Purpose. This study aims to analyse the role and importance of modern intermodal logistics terminals in achieving efficiency in the integration of transport networks and to evaluate the impact of digitalisation and organisational coordination on the efficiency of intermodality in Bulgaria.

Findings. The analysis revealed average terminal efficiency, primarily due to insufficient coordination among supply chain participants and increased cargo idle time. Infrastructure limitations are less critical than partial digitalisation and the lack of comprehensive digital solutions. The overall efficiency of intermodal terminals in Bulgaria is rated as average, with 47% of respondents rating it only as “satisfactory”. Weak coordination between operators (66% of participants) and insufficient digital integration were cited as key issues. The latter point is supported by the fact that 69% of specialists rated the current level of digitalisation as average or low, and 63% consider its improvement a key development priority. The lack of coordination and digital solutions directly correlates with operational losses, as cargo dwell times reach 3-6 hours; however, with better organisation, this can be reduced to 1-3 hours. According to 82% of respondents, these delays lead to increased logistics costs. The results confirm that the development of digitalisation is the foundation for improved coordination and operational efficiency, making it a key factor in optimisation.

Implications. Digital integration is emerging as a strategically more important factor in the current development of intermodal terminals, and skilled integrated information management, especially against the backdrop of the country's strategic geographical location, will lead to rapid opportunities to improve the overall efficiency of intermodal terminals. Standardisation of electronic customer relationship management (e-CRM) documents and the use of full automation capabilities, including optical character recognition (OCR), radio-frequency identification (RFID), and terminal operating system (TOS) integration, are also recommended for future studies.

Keywords: Digitalisation, Intermodal Terminals, Logistics Hubs, Supply Chain, Transport Infrastructure.

1. Introduction.

Modern logistics is impossible without the construction and development of Intermodal Logistics Hubs, which are designed to ensure fast, efficient, cost-effective and sustainable transfer of goods between different modes of transport. In this regard, they are a key link in the interaction between rail, road, water, and air transport, allowing for the development of reliable international trade in general.

For certain regions and countries, it is decisive for the economy due to the economic benefit of passing cargo flows through them. Strategic transport corridors, such as TEN-T, determine access to international markets and, consequently, the competitiveness of national and regional economies. In this regard, intermodal logistics hubs are of decisive importance. For example, in the Danube region and the Balkans, the development of intermodal logistics hubs serves as both a condition for effective connectivity with the rest of Europe and a bridgehead for transferring cargo flows from and to Asia and the Middle East. Finally, well-established intermodal logistics connections enable the balancing of cargo flows.

However, the construction of effective intermodal logistics hubs is associated with overcoming several diverse challenges (infrastructural compatibility, digitalisation, inconsistency in regulatory regimes, various environmental requirements, etc.). The successful overcoming of these inherently diverse challenges determines the economic viability of operating intermodal logistics hubs. To overcome the aforementioned challenges, it is necessary to employ diverse efforts, including finding investments, implementing transparent procedures, and intensifying cooperation between state authorities and various operators and forwarders. The economic results of operating an intermodal logistics hub are a key criterion for evaluating its effectiveness. However, more important than the direct benefits are the development opportunities that the region receives by attracting new cargo flows and ensuring sustainable and competitive transport.

This study aims to investigate and analyse the efficiency of Bulgarian intermodal terminals and their place, role, and integration in European and global freight transport.

2. Literature Review.

The development of intermodal logistics hubs is inevitably considered in terms of the challenges that need to be overcome in their construction and operation. Various perspectives exist on this topic (Hoffelner et al., 2024). The primary challenges are related to infrastructure design and compliance with various constraints. Caris et al. (2008) examine the main challenges in the planning and development process of intermodal transport, including the role of terminal location, possible infrastructure constraints and overall intermodal network planning.

Witte et al. (2012) investigated problems related to infrastructure bottlenecks in the European transport network. This study aimed to examine the influence of the locations of intermodal logistics hubs and their respective capacities on freight transport. In this regard, Tadić et al. (2019) developed a robust methodology for planning and developing intermodal terminals, including location selection, cargo capacity options, specific infrastructure features that meet stakeholder requirements, and the principles of sustainable development, which is an essential aspect in the preparation and planning of an infrastructure project today.

Khaslavskaya and Roso (2020) conducted an extensive study on infrastructure connectivity, spatial positioning, railway infrastructure constraints, investment barriers, and spatial land-use conflicts. Rodrigues et al. (2021) presented the negative impact and consequences of underdeveloped network infrastructure, as well as the lack of sufficient clarity in the regulatory framework and constraints regarding connectivity with existing transport corridors.

Wilmsmeier et al. (2011) demonstrated the importance of infrastructure and policies in shaping the development of European corridors, which, in turn, influence the location of intermodal logistics hubs. Lee (2015) examines the role of the urban environment in the planning, construction, and development of intermodal terminals. Zain et al. (2022) explored this aspect of intermodal terminal construction. The requirements of logistics processes must not be ignored in the design process (Anguelov & Kenova, 2018; Popov et al., 2019).

Information and communication technologies have profoundly impacted the planning, design, and overall development of modern intermodal logistics hubs. Various political and project documents, such as those of the European Commission (2024), have also influenced the design.

Overcoming various technological challenges is crucial for the effectiveness of intermodal logistics hubs (ILHs). Kine et al. (2022) present a comprehensive overview of the applied technologies (IoT, sensors, platforms, and automation) from the perspective of their potential applications in the subject area. In this context, the capabilities of geographic information systems (Tsonkov & Kostev, 2023) and artificial intelligence (Ilieva et al., 2019; Vural et al., 2020) are crucial tools that can significantly contribute to the optimisation and coordination of intermodal transport processes.

Several studies have focused on the specific applications of information and communication systems. For example, Hervás-Peralta et al. (2019) conducted a thorough investigation into the specific functionalities of terminal operating systems, focusing on seaports and dry ports. Study has precisely identified the modules that are critical for terminal operational efficiency, capacity, and reducing congestion and emissions.

Zajac et al. (2025) analysed the opportunities for implementing and utilising digital tools among SMEs in Central and Eastern Europe within the transport, logistics, and forwarding sectors. The main barriers to the low level of digitalisation in planning are a lack of sufficient information, organisational inertia, and prioritisation of financial costs by enterprises with limited capacity.

On the other hand, Dimitrov and Gigov (2022) conducted a study that shows the potential of digitalisation and, more specifically, the use of the capabilities of technologies such as blockchain, which can lead to an overall improvement in logistics processes and, as a result, a positive impact and creation of added value in supply chains at a global level.

Turi and Boglut (2024) examined regional specificities in terms of operational prerequisites, such as connectivity, intermodal terminal infrastructure, and cost efficiency.

Raza et al. (2023) focus their attention specifically on the digitalisation of maritime logistics. They identified levels of digital maturity, believing that despite the available technological progress, digital transformation, especially in shipping, is lagging for several reasons, among which conservative organisational models and structural barriers stand out.

Simultaneously, Giusti et al. (2019) expressed the reasoned opinion that technological challenges at the systemic level are crucial. Alaei et al. (2024) present interesting results from a survey of logistics company representatives. They highlighted the role and importance of information systems and real-time data acquisition.

Varese et al. (2022) analyse dry ports from the perspective of environmental sustainability. They study various environmental aspects, such as emissions, noise, development, connection with SDGs, and the lack of standardised assessment tools. The authors conclude that despite the growing importance of dry ports as a green practice in transport and trade, their environmental aspects are still relatively poorly studied, and propose a new conceptual framework for assessing the environmental dimensions of dry ports.

Environmental and energy aspects of the modern economy are significant manifestations. From this perspective, effective resource management, achieving energy efficiency, and proper management of energy logistics centres are of utmost priority for achieving a sustainable economic model. Yadollahi et al. (2024) focused on the effective management of energy logistics hubs, ensuring the proper use of raw materials to achieve higher results, lower costs, and personnel protection.

Lättilä et al. (2013) used a simulation model to analyse how the use of dry ports linked to seaports by rail can reduce CO₂ emissions and transport costs compared to direct road transport. It has been mathematically proven that an optimum function can be achieved. Their results showed the impact and potential of different energy scenarios. Simultaneously, they provide considerable clarity on the potential of dry ports for more sustainable transportation and alleviating pressure on seaports.

Emissions, transport time, and costs can be reduced by using the most appropriate intermodal chain for a given scenario. In this regard, Beškovnik and Golnar (2020) examined different routes in Central Europe. In the same context, López-Acevedo et al. (2024) showed that even for short distances, an adequately designed intermodal connection can significantly reduce emissions.

Goodarzi et al. (2024) developed a stochastic optimisation model that can increase the sustainability and environmental efficiency of intermodal freight transport networks. This analysis shows that even with minimal investments in preparedness and consolidation, it has the capacity to lead to significant cost reductions and increased sustainability of the transportation system. Mata-Lima et al. (2019) and Karaš (2024) focused attention on the environmental aspects related to the expansion and development of intermodal terminals, logistics connections, and the overall transport network. At this point, it would not be an exaggeration to state that efficient logistics is a vital component of overall sustainable economic development in the region.

Currently, the development of national, union, and regional economies relies heavily on effective logistics as a fundamental factor for achieving sustainable development. However, transport networks have a strong impact on the environment. This leads to the conclusion that the development and optimisation of their use, through the introduction of new technologies, can significantly mitigate the consequences of such an impact. However, it is hoped that the effect will be synergistic and encompass social and economic dimensions. Krachunov et al. (2021) examine in depth the main barriers to the development of transport and logistics systems in Bulgaria. Their analysis primarily focused on the significance of these systems within the UN's Sustainable Development Goals. The study developed by Petrov and Tsonkov (2023) confirmed these considerations.

The planning, construction, and development of intermodal terminals and comprehensive logistics hubs have a significant impact on other crucial aspects, such as ensuring security and addressing challenges related to staff training (Stoykov, 2018).

3. Methodology.

This study aims to analyse the role and importance of modern intermodal logistics terminals in achieving efficiency in the integration of global, regional, and local transport networks. At the same time, through the study's methodology, the impact of the level of digitalisation and organisational coordination on the efficiency of intermodality in Bulgaria will be assessed and analysed. The study focuses on intermodal logistics terminals and logistics hubs in Bulgaria. The subject of the study is the processes of transshipment, coordination, information exchange, and the use of digital technologies within these terminals.

According to reports from the UNCTAD and the International Transport Forum, several thousand intermodals and container terminals operate globally, forming the backbone of international freight flows.

Bulgaria currently has five main intermodal terminals, which are located at strategically important logistical connections: Sofia (from the perspective of the capital and largest city) and a connection with Western Europe; Plovdiv, a south-central region, which provides the connection between the interior of the country and international transport corridors, including a connection between Central Europe, the Balkans, Turkey, and the Middle East; the intermodal terminal in Ruse, which provides Bulgaria's connection with Central and Northern Europe; and the intermodal terminals in Burgas and Varna, which provide a connection to the Black Sea region, the Caucasus, Turkey, and the Middle East.

All operating intermodal terminals in Bulgaria are integrated into core and extended TEN-T networks. However, some operate with limited capacity and could benefit from significant efficiency improvements. According to the Integrated Transport Strategy of Bulgaria until 2030 (Ministry of Transport and Communications of the Republic of Bulgaria, 2017), the terminals in Plovdiv and Ruse play a leading role in the development of combined transport. Detailed technical parameters and analyses of their zones of influence have been developed to this end.

Strategic analyses indicate a growing role for containerised and combined freight transport in Bulgaria, particularly on the Orient/East Mediterranean and Rhine–Danube routes. Container traffic forecasts have been prepared for the intermodal terminal in Ruse, which anticipates a sustainable increase in container volume in the medium and long terms, in line with the development of international freight flows and TEN-T corridors. These trends confirm the role of intermodal terminals as logistics hubs in increasing freight turnover.

The strategy identifies combined transport as a priority area for development, although the share of intermodal transport in the country's total freight turnover remains relatively limited. In the aforementioned document, intermodal transport is considered a strategic priority aimed at increasing the share of rail transport, thereby reducing the load on road infrastructure and enhancing freight chain efficiency.

The planned measures and investments until 2030 aim to gradually increase the volumes of intermodal transport, in line with European policies for sustainable transport. According to the National Plan for the Development of Combined Transport in the Republic of Bulgaria until 2030 (Ministry of Transport and Communications of the Republic of Bulgaria, 2022), a limited number of rail-road intermodal terminals are operating, with the main active facilities located in Plovdiv, Stara Zagora, and Burgas, and a small terminal for cross-docking operations at the Sofia railway junction (Voluyak station).

The intermodal terminal in Plovdiv has a capacity of 57,600 TEU per year and is the only terminal with a published price list and conditions for non-discriminatory access (National Railway Infrastructure Company, 2017; Terminali AD, 2025). At the same time, there is a lack of adequate territorial coverage of Northern and South-Western Bulgaria, with approximately two-thirds of the population and a significant part of the production capacities not being effectively served by the existing intermodal terminals, which limits the development of combined transport at the national level. To achieve the objectives of the study, a combined methodological approach is applied.

3.1. Desk Research and Documentary Analysis.

The aim is to establish a theoretical framework and outline the context in which the development of intermodal transport occurs:

- Research publications and studies related to the role of intermodal terminals in the modern transport map

- The primary regulatory documents, as well as reports on the development of transport infrastructure, were studied.

- Basic statistical data related to transport operators and national, European, and global institutions in the field of intermodal transport were studied and analysed.

3.2. Survey Component.

A direct survey was conducted among specialists in logistics, forwarding, and transport. Structurally, it contains 15 questions distributed in the following thematic blocks:

- Respondent profile – professional experience, field of activity, education.

- Use of intermodal terminals.

- Assessment of the effectiveness and digitalisation of intermodal terminals.

- Problems and opportunities for development.

The sample was selected because of the participants' specific professional competence. Given the method of conducting the survey, which involves on-site direct surveying through a pre-prepared questionnaire filled out by interviewers based on the answers learned from respondents, the number of respondents is relatively limited (32).

3.3. Semi-Structured Interviews.

Short interviews were conducted with specialists directly involved in transport and terminal operations (dispatchers, forwarders, and terminal operators). The interviews aimed to supplement the survey data with qualitative observations and professional assessments. In this way, seven specialists were interviewed, each interview lasting 10-15 minutes. The following accepted methods were employed to process and interpret the empirical data: descriptive statistical analysis, comparative analysis of assessments across respondents.

Substantive analysis of open questions and interviews was conducted, including the identification of main themes and recurring issues. The following limitations include sample size and targeted nature; differences in professional experience among respondents; and incompleteness of publicly available operational data on intermodal transport and connections.

Table 1 systematises the research hypotheses, the corresponding conceptual categories, the questionnaire questions, and the testing methods used. A clearly traceable logical sequence between the theoretical framework, empirical tools, and analytical methods is ensured, allowing the hypotheses to be systematically verified. The methodology of this study encompasses several approaches,

including documentary analysis, surveys, and semi-structured interviews.

Thus, this study aims to analyse the structural characteristics of intermodal logistics terminals in Bulgaria in more depth.

The proposed methodology provides a sufficiently reliable basis for collecting information and analysing existing practices, from which the main challenges facing intermodal terminals in Bulgaria can be identified. The chosen combination of quantitative (survey) and qualitative (semi-structured interviews) methods can provide valuable insights into the current level of digitalisation, the challenges of achieving high digital efficiency, and possible development solutions from this perspective.

Table 1. Operationalisation of Research Hypotheses.

Hypothesis	Element	Description
Hypothesis 1 (H1): Higher operational efficiency can be achieved through digitalisation in intermodal terminals, primarily through reduced cargo dwell time, faster processing, and improved traceability.	Concept	Digitalisation: Building comprehensive information solutions – Terminal Operation Software (TOS), which includes modules covering basic terminal operations – planning, execution, control, traceability, integration and operations analysis. Efficiency: reduced downtime, reduced possibility of errors, faster processing, consistency and traceability. Digitalisation assessment.
	Survey questions	Processing time. Overall efficiency assessment.
	Indicators for the H1	Digitalisation rating (scale 1–5). Efficiency rating (scale 1–5). Self-reported average dwell time.
Hypothesis 2 (H2): The degree of coordination and interaction between individual transport operators (road, rail, and sea/river) directly impacts the quality and reliability of intermodal transport services within national and regional logistics networks.	Concept	Coordination: scheduling, communication between companies, exchange of documents, and synchronisation between rail/road/sea operators.
	Survey questions	Coordination assessment; most common problems; suggestions for improvement. Coordination rating (scale 1–5).
	Indicators for the H2	Frequency of mentioned problems, such as “poor communication” or “inconsistency”. Recommendations for improvement.
Hypothesis 3 (H3): The limitations of the infrastructure and organisational processes of intermodal terminals in Bulgaria are a significant factor hindering the full development of intermodal transport, despite the country’s existing geostrategic potential.	Concept	Constraints: terminal capacity, rail connections, cranes, warehouse facilities, administrative procedures. Most common problems.
	Survey questions	Most needed improvements. Regions with potential.
	Indicators for the H3	Frequency of choosing “insufficient infrastructure” / “lack of automation”. Preferred development solutions.

4. Results.

4.1. Profile of the Respondents (Part A).

The survey was conducted from January to March 2025. It involved 32 respondents employed in key units of the logistics chain, including forwarding (34%), road transport (25%), rail transport (13%), and terminal/port activities (19%).

The respondents who participated in the quantitative study were pre-selected based on their direct experience in working with intermodal terminals and specific logistics operations.

A majority of respondents (78%) reported performing specific activities related to intermodal terminals and operations on a daily or weekly basis. The respondents' answers show that, most often in the country, intermodality is used primarily in the form of a combination of road and rail (56%) and road and sea (44%).

The data provided is clear about the role of intermodal terminals in the modern logistics chain and the importance of the connections they provide at the national, regional, and international levels. Detailed information on the respondents participating in the quantitative study is provided in Table 2.

Table 2. Profile of the Respondents.

Question 1: What industry do you work in?		
Industry	Number	%
Freight forwarding/ 3PL	11	34
Road transport (international/ domestic)	8	25
Rail transport/ Operators	4	13
Port/ terminal operators	6	19
Other (logistics software, consulting etc.)	3	9
Total	32 Respondents	100%
Question 2: How many years of experience do you have in the sector?		
Experience	Number	%
Under 1 year	2	6
1 – 3 years	9	28
4 – 7 years	13	41
Over 7 years	8	25
Total	32 Respondents	100%
Question 3: How often do you work with intermodal terminals?		
Frequency	Number	%
Daily	10	31
Weekly	15	47
Rarely (in specific project/ campaigns)	7	22
Never	0	0
Total	32 Respondents	100%
Question 4: Which modes of transport do you usually combine? (multiple choice → total may be > 32)		
Combination of transport	Frequency of choice	% of respondents
Road + Rail	18	56
Road + Sea	14	44
Rail + Sea	9	28
River + Road	4	13
Other	2	6
Question 5. Which intermodal terminals do you use most often? (open question → summarised categories)		
Terminal	Number of mentions	
Plovdiv Intermodal Terminal	14	
Varna Port	10	
Burgas Port	7	
Ruse (River + Rail)	5	
Sofia Dry Port + Rail	4	
Other/ Sporadic	3	

Based on the profile data presented, the sample included respondents, who were professionally competent, a prerequisite for the high reliability of their answers. The respondents had over 3 years of professional experience, and the majority reported daily or weekly contact with operations at intermodal terminals. These data guarantee the expertise of the participants and assess the effectiveness of intermodal terminals, related to several very critical aspects: on the one hand, the level of digitalisation itself, and on the other hand, the quality of the information exchange process, which should guarantee reliable coordination between individual operators, as well as an overall view related to the main specific challenges that stand out in the development of intermodal transport in Bulgaria.

At this stage, all hypotheses were tested by comparing assessments, identifying problems, and proposing solutions.

4.2. Functioning Assessment (Part B).

Almost half of the respondents (47%) gave an efficiency rating of “3” on a five-point scale, with 25% rating it “4” and only 6% rating it “5”. This indicates that the terminals are operating at a satisfactory, albeit far from optimal, level. The fact that 22% of the responses had low ratings (1 and 2) may also suggest the presence of severe difficulties. This suggests that significant improvements are necessary at the systemic level, encompassing the entire management, both at the operational organisation level and in the provision of resources (Table 3).

Table 3. Assessment of the Effectiveness and Digitalisation of Intermodal Terminals.

Question 6: Rate the efficiency of intermodal terminals in Bulgaria (1 = very low, 5 = very high)		
<i>Assessment</i>	<i>Number</i>	<i>%</i>
1	1	3
2	6	19
3	15	47
4	8	25
5	2	6
Total	32	100%
Question 7: Rate the level of coordination between different transport operators (1–5)		
1	2	6
2	10	31
3	14	44
4	5	16
5	1	3
Total	32	100%
Question 8. How do you assess the level of digitalisation (information systems, tracking)? (1–5)		
1	1	3
2	9	28
3	13	41
4	7	22
5	2	6
Total	32	100%
Question 9. The average processing/delay time for a truck or container is?		
<i>Time interval</i>	<i>Number</i>	<i>%</i>
Under 1 hour	3	9
1 – 3 hours	16	50
3 – 6 hours	10	31
Over 6 hours	2	6
Cannot estimate	1	3
Total	32	100

Regarding the coordination between operators of different modes of transport (road, rail, sea/river), the results are definitely focused on medium and low ratings. A total of 44% of respondents rated coordination with a “3”, and 31% with a “2”. Suppose coordination is rated as a medium to low priority. This means that various forms of communication and interaction, including the processes of coordinating transport schedules and exchanging documents between the various participants in the logistics chain, are not performed at a sufficiently high level. This, in turn, leads to additional time delays, which are the basis for the creation of further transport problems, including inadequate relationships between the various stakeholders involved in the logistics transport process. This result directly confirms Hypothesis 2, which posits that the level of coordination significantly impacts the quality and reliability of intermodal services.

In turn, the level of digitalisation is rated as being medium. 41% of respondents rated it “3”, and 28% rated it “2”. This result suggests that digital systems are available for managing and tracking shipments and providing basic data exchange capabilities. It is worth noting that this relatively unsatisfactory assessment is an indicator of insufficient quality, and in some cases, a possible direct lack of integration between the individual systems, which would otherwise provide sufficiently reliable data exchange and a higher degree of automation. We can say with a high degree of certainty that this result is indicative of the simultaneous use of separate systems, which, however, are characterised by a relatively low degree of connectivity between them (for example, TOS systems, Excel spreadsheets, and separate GPS platforms). It is natural that with such an adopted way of working, this will inevitably lead to severe difficulties related to the continuous exchange of data. This result confirms Hypothesis 1, which posits that digitalisation is a priority factor for improving efficiency and reducing cargo dwell time. The specific results of these characteristics can be analysed using the dwell time indicator. Half of the respondents (50%) reported an average dwell time of 1 to 3 hours.

This result is a relatively normal time required for intermodal processing. However, it should be noted that 31% of respondents indicated a more extended time range of 3–6 h for downtime. This result is indicative of the problems that can be identified in terms of congestion, delays, or insufficient capacity. This result should be commented on, especially considering that only 9% of respondents reported downtime of less than 1 hour. This is a clear indicator that there are bottlenecks that can be addressed to improve efficiency. These results indicate the presence of visible and significant differences in the operational speed. This means that improving infrastructure and better process management would have a tangible effect. These data and analyses confirm Hypothesis 3, which relates to the impact of infrastructure constraints.

As a summary of everything analysed so far, we can conclude that intermodal logistics terminals in Bulgaria operate at an average level of efficiency, which means that their full capacity is not currently being sufficiently utilised. The main challenges in this direction are related to the insufficient degree of coordination between operators, incomplete or partial digital integration of processes, and lengthy interruptions in cargo handling. These problem areas are currently critical points, but at the same time, they clearly highlight potential opportunities for improvement, which should be further analysed in Part B of the study.

The observed distribution of ratings shows that perceptions of terminal efficiency are significantly related to the level of digitalisation and the quality of coordination between operators. Respondents who rated digitalisation higher tended to give higher ratings of efficiency, suggesting a trend towards optimising logistics processes, where more comprehensive information systems and cargo flow tracking are implemented. Simultaneously, lower coordination ratings correspond to longer dwell times and difficulties in coordinating operations among road, rail, and sea transport. These results do not establish a formal statistical relationship, but clearly outline a pattern in the participants’ professional observations, which is essential for interpreting the hypotheses, as shown in Table 4.

Table 4. Descriptive Correlation of Digitalisation, Operational Coordination, and Intermodal Terminal Efficiency.

Respondent group according to digitalisation score	Average efficiency score	Average coordination score	Comments / Interpretation
Score 1 – 2 (low level of digitalisation)	2.3	2.2	“Systems are not integrated”, “Many paper documents are used”
Score 3 (medium level of digitalisation)	3.0	2.8	“Processes are functional, but there are delays in information exchange”
Score 4 – 5 (high level of digitalisation)	3.8	3.4	“Follow-up is easier”, “Fewer errors and faster processing”

Table 4 clearly shows that a higher digitalisation score is associated with higher efficiency and coordination. The distribution of the mean scores shows a clear trend: respondents who rated digitalisation as low (1–2) also reported lower efficiency (approximately 2.3) and weaker coordination (approximately 2.2). With average scores (3) and efficiency (3), the process is functional but not optimised. With high scores for digitalisation (4–5), efficiency increased to approximately 3.8 and coordination to approximately 3.4, indicating better coordination, reduced downtime, and faster processing. These data indicate that digitalisation should be perceived as a means to

increase the efficiency of processes in intermodal terminals; namely, it is a necessary factor for achieving efficiency, especially given the ongoing development of ICT, including in combination with AI. Better coordination between individual transport operators has been achieved in these terminals, where more integrated information systems, including TOS, electronic waybills, and GPS tracking, are in place. This better coordination is also expressed in improved cargo processing time. This, in turn, categorically confirms Hypothesis 1. Table 5 clearly shows that low coordination between transport operators is associated with longer terminal dwell times.

Table 5. Descriptive Correlation between Operational Coordination and Terminal Downtime.

Respondent Group by Coordination Score	Most Frequently Reported Downtime	Average Downtime Range	Typical Operational Scenario
Score 1–2 (low coordination)	3–6 hours	Medium–high	Frequent delays, waiting for train sets, issues with document transfer, lack of operator synchronisation
Score 3 (medium coordination)	1–3 hours	Moderate	Functional processes with occasional delays during terminal loading
Score 4–5 (high coordination)	Under 1 hour – 1–3 hours	Low	Efficient communication, fast turnaround, clear planning, effective information exchange

Respondents who considered the level of coordination to be low and rated it with a score between 1 and 2 cited significant delays and downtime between 3 and 6 hours as the main reason. This, in turn, can be considered an indicator of the following important elements and possible bottlenecks:

- Lack of a sufficiently good level of coordination related to the synchronisation of rail and road transport schedules.

- Insufficient quality of document flow, which also leads to delays.

- Lack of clearly defined communication channels and direct connections between operators.

- Lack of good planning related to the use of terminal equipment and its capacity.

When assessing the coordination level (3), the downtime was significantly reduced, falling within the 1-3 hours range.

Such downtime is within the acceptable operational level but cannot be considered optimal. With high coordination (4–5), the dwell time is less than one hour or in the range of 1–3 hours, which implies:

- Pre-planned unloading/loading slots.
- Clear communication between participants in the logistics chain.
- Effective exchange of documents and data.

These results outline a clear relationship between the coordination level and the time goods spend in the intermodal terminal. The better the coordination is developed and the more effective it is, the less time goods spend in the terminals.

This observation, in fact, makes clear the dependence of operational efficiency on the interaction and cooperation among the different transport operators, as well as on the intermodal operator itself. This judgment reveals the potential and content of the overall coordination mechanism for the significant reduction of the time spent by goods (including, among other things, standardised communication protocols, digital data exchange and responsible planning). This, in turn, will lead to the overall optimisation of the intermodal processes. This result directly supports Hypothesis 2.

The systematised results of the study show that the efficiency of intermodal logistics terminals in Bulgaria is directly related to the level of digitalisation and the degree of coordination between individual transport operators.

Conversely, insufficient coordination and fragmented use of digital systems result in delays, higher operating costs, and lower overall efficiency of the logistics chains. These trends highlight the serious challenges and provide a clear idea of the barriers that stand in the way of the full development of intermodality in Bulgaria. The next part of the analysis focuses on identifying the main problems and potential directions for optimisation and achieving sustainable development in the operation and functioning of intermodal terminals.

4.3. Problems and Opportunities for Development.

Figure 1 clearly shows that the respondents perceive coordination between transport operators as the most significant challenge for intermodal terminals. At most, 21 respondents (66% of the sample) indicated that weak coordination was a serious and significant problem. T

he dimensions of the more generally formulated problem can be complex, but mainly reflect numerous unpleasant situations related to schedule discrepancies, unnecessary waiting times during cargo transfer, and delays in communication between different types of operators, including rail, road, and port. The problem outlined is closely associated with the extended dwell time observed in the preceding section of this study. In fact, the result of weak coordination is categorically one of the most serious barriers to the operational efficiency of intermodal terminals.

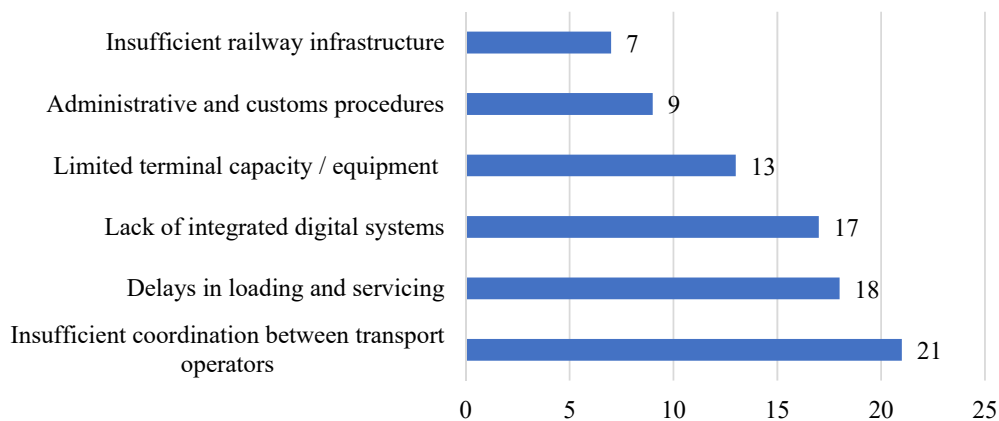


Fig. 1. Responses to the Question “What Are the Most Common Problems You Observe? (Multiple Answers Possible)”.

The second most common problem is the lack of sufficiently integrated digital systems in the industry. The use of separate tracking systems is not a sufficient condition to achieve a good level of efficiency, especially in the presence of the following hindering factors: lack of a single platform through which to exchange data in real time, duplication of information, duplication of work, manual operations, and increased probability of errors. This analysis again confirms Hypothesis 1, which states that digitalisation is a significant priority factor for achieving the efficiency of intermodal terminals.

The third problem identified is the limited terminal capacity, including processing equipment and storage facilities. This is especially evident during busy periods and at terminals with complex cargo flows. However, it is interesting that respondents do not consider infrastructure as a primary problem, but rather as a secondary one that can be better managed through improved organisation and digital planning. The data on the impact on costs are particularly indicative: 82% of participants believe that the current state of the process organisation increases logistics costs. This leads to the conclusion that the improvement of coordination, resulting from the enhanced level of digitalisation in the services provided at the intermodal terminal, can have a direct positive economic impact on operators and customers (Fig. 2).

The data on the impact on costs is particularly telling: 82% of respondents believe that the current state of process organisation in intermodal terminals leads to increased logistics costs. This means that problems that occur at the coordination level should not be interpreted narrowly as merely operational difficulties. In contrast, they have a much more serious resonance and direct financial dimensions. It should also be borne in mind that more extended downtimes inevitably lead to higher labour costs and increased downtime costs of the vehicles.

Simultaneously, a significant delay in downtime can also reflect poorly on additional planning, and sometimes the delay can lead to penalties for late deliveries. In the context of intermodality, this is critical because its logic is based on minimising costs through optimised connectivity between the transport modes. Simultaneously, more than 40% of respondents indicated that costs were increasing significantly, which led to the conclusion that, unfortunately, delays should not be considered isolated cases.

This model is characteristic of an environment with no centralised management of freight flow and a common digital platform for exchanging information between operators. In other words, the costs do not stem solely from the physical infrastructure but, to a large extent, from how it is managed and integrated into the logistics network.

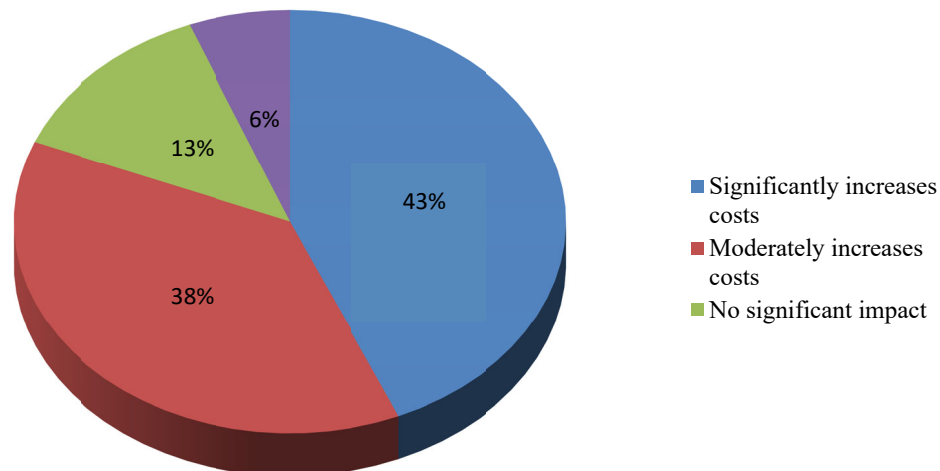


Fig.2. Responses to the Question “How Does This Affect Logistics Costs?”.

These findings lead to a more general conclusion that improving coordination and digitalisation can have a direct economic impact. This economic impact is expressed not only for transport operators (lower operating costs and shorter delivery cycles) but also for customers (higher predictability, shorter lead times, and lower final logistics costs). This supports the understanding, shared by the authors of this article, that intermodal terminals should be perceived as network management units, the efficiency of which results in the entire supply chain. In this sense, considering intermodal terminals solely as infrastructure objects is extremely limiting and inconsistent with their current complex functionality and status quo.

The results of question 12 (Fig. 3) clearly show that respondents consider digitalisation and integration of information systems as the most important priority for improvement (63%). This suggests that specialists view information flow as the key regulator of operational efficiency in intermodal terminals.

The presence of working but disconnected systems leads to delays, data duplication, and manual document processing, which in turn directly affects downtime and overall costs. Therefore, Hypothesis 1 is confirmed: digitalisation is a fundamental factor in increasing the efficiency and transparency of processes.

In second place in terms of importance (56%), respondents indicated the need to improve coordination between operators. This result consistently appeared in Part B, where coordination received medium-to-low ratings. It is essential to emphasise that coordination is not only communication, but also a process of synchronising schedules, capacities, and information events between road, rail, and maritime transport.

All that has been said so far leads to the conclusion that poor coordination inevitably results in longer waiting and dwell times for goods in intermodal terminals. Therefore, these observations and results confirm Hypothesis 2, which posits that the level of coordination and interaction among individual transport operators directly affects the quality of intermodal transport services.

Simultaneously, 47% of respondents reported the need to expand infrastructure modernisation, and another 38% reported the need to improve railway infrastructure. Their positioning as secondary constraints to effective development shows the priority of understanding and achieving efficiency. Although improving and expanding transport infrastructure is fundamental, it comes only after efforts to better manage the existing infrastructure. That is, the possibility of expanding and improving infrastructure does not exclude the problems of poor coordination, which would inevitably arise at some point, even after large-scale infrastructure improvements. That is, the participants in the study give significant priority to better coordination and connectivity between individual transport operators rather than infrastructure investments, which are also characterised by low coordination. This conclusion confirms Hypothesis 3, which identifies limitations in the available infrastructure and the overall organisational process for managing intermodal terminals as the most important challenges to the effective development of terminals.

To obtain greater depth and scope, the quantitative study was supplemented with qualitative data to provide a more expert assessment of the critical points outlined in the management and development of intermodal terminals in Bulgaria. Seven semi-structured interviews were conducted with proven professionals whose main activities were the management and operation of intermodal terminals. The interviews lasted 10-15 minutes, with questions sent in advance so that the interviewees could prepare. Supplementary questions were asked during the interview to further clarify the expert's point of view. Primary information on personal professional observations, opinions, assessments, and suggestions that the classic questionnaire could not cover was collected and analysed.

The responses received were analysed through thematic (content) analysis, with an emphasis on recurring ideas and arguments related to the potential, problems, and opportunities for the development of intermodal terminals in Bulgaria.

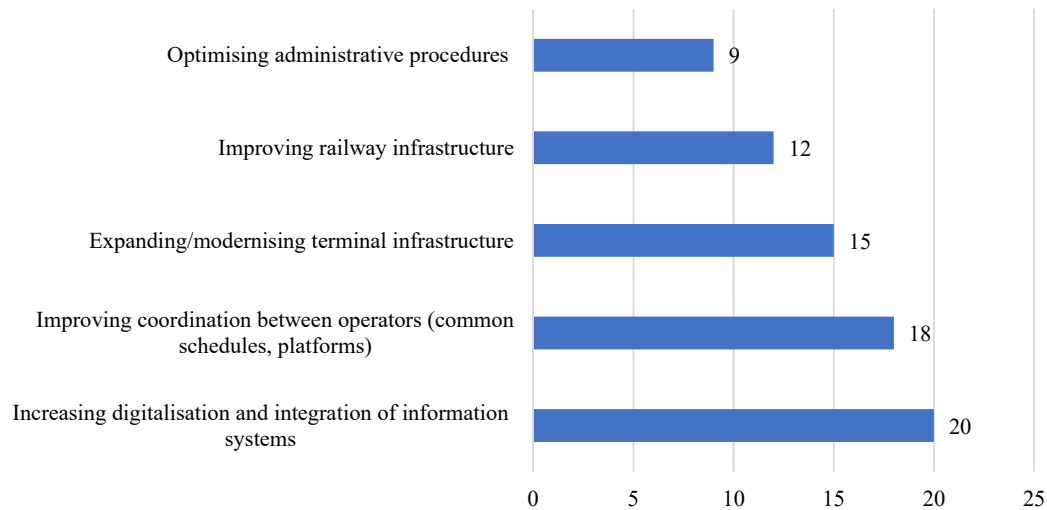


Fig. 3. Responses to the Question “Which Improvements Are Most Important? (Multiple Choices)”.

Question 1: In your personal opinion, is there potential for growth of intermodal transport in Bulgaria? Give your reasons.

The answers to the first question reveal a widely held belief that Bulgaria has significant potential for developing intermodal transport. Most interviewees cited the country's geostrategic location (serving as a crossroads between Europe, Asia, and the Middle East) as the primary argument, along with the presence of major trans-European corridors. The fact that there are opportunities to finance the construction of trans-European corridors with community funds is also not without attention. Most interviewees also responded to the opportunity to redirect freight flows from road to rail transport, citing the benefits of reduced costs and smaller environmental footprints. Some experts emphasise that there is potential, but it remains unused to its full capacity for many reasons, mainly due to weak organisation and insufficiently developed infrastructure. This observation leads to the conclusion that the growth in the development of intermodal terminals currently depends mainly on improving the management and coordination mechanisms in the terminals. If this is drastically improved, the demand should also increase significantly.

Question 2: Which city or region do you think has the greatest potential for the development of an intermodal logistics hub? Why?

The expert survey revealed several leading regions, including Plovdiv, Varna, Ruse, and Sofia. It should also be noted that there are significant differences between the above-mentioned cities/regions in several aspects: geographical location, existing terminal infrastructure and its current capacity, and opportunities to improve transport connectivity and intermodality. At the same time, they all have access to main transport corridors, are included in the comprehensive TEN-T network, and offer different opportunities to combine the movement of goods across different modes of transport.

1. Plovdiv (mentioned by most interviewees).

Respondents specifically emphasised that Plovdiv has several strong aspects that could make it a leading intermodal logistics hub. First, its geographical location is in the interior of the country, which is part of the Orient – East Med Corridor, connecting Central Europe, the Balkans, Turkey, and the Eastern Mediterranean. The second is the presence of a well-developed industrial zone (Trakia Industrial and Economic Zone). The presence of a large number of manufacturing and distribution companies in the region should not be ignored, as this is a prerequisite for increased interest in an intermodal terminal. This creates a natural cargo formation, a key factor in sustainable intermodal terminals.

Good accessibility to the Trakia motorway and the Plovdiv railway junction was also noted, enabling the effective distribution of flows across the country. Plovdiv is perceived as a logistics hub of intra-national importance, with potential for expansion into a regional distribution centre.

2. Varna and Burgas (port axes).

Interviewees emphasised that Black Sea ports are entry and exit points for international cargo flows, especially to Asia and the Black Sea region. Varna is seen as more suitable for the development of intermodality due to:

- The presence of rail connectivity in the immediate vicinity of the terminal.
- The possibility of working with containerised cargo.
- The possibility of developing a “Sea + Rail + Road” triage.

Varna has the potential for global connectivity, but organisation and synchronisation remain challenges.

3. Ruse (gateway to the Danube and Central Europe).

Some respondents highlight Ruse because of: river transport, rail and road; positioning on the North-South corridor; the potential for creating a distribution centre in the Balkans and Central Europe. Ruse is a strategic “border” hub, but its capacity is sensitive to seasonality and infrastructure maintenance.

4. Sofia (dry terminal).

Some experts note that Sofia is a natural terminal/ distribution hub. However, it is not optimal for the primary processing of cargo flows, as cargo is received after distribution has already occurred. Sofia functions more as a secondary hub than as a primary intermodal centre. The responses indicate that the potential for developing intermodal transport in Bulgaria is not concentrated in a single city, but rather distributed across a network. The logic of the expert opinions is as follows:

- Plovdiv functions as domestic national hub, oriented towards distribution and industry.
- Varna serves as international entry/exit corridor.
- Ruse acts as transit and cross-border connection with Northern and Central Europe.
- Sofia operates as distribution logistic center with supporting functions.

This leads to the conclusion that the model for developing intermodal terminals should be decentralised, thereby excluding a single, larger terminal serving the entire country.

Question 3: What do you think would lead to the greatest improvement in the functioning of intermodal terminals in Bulgaria?

The answers of the interviewed specialists outline a clearly expressed and shared understanding, which, on the one hand, reveals coherence and, on the other hand, multi-layeredness across the various aspects of improving efficiency.

First, the view emerges that the qualitative improvement of services provided by intermodal terminals depends mainly on more effective process organisation, as well as on higher levels of cooperation and coordination among individual transport operators. Investments in infrastructure are also perceived as an opportunity, but only if they are accompanied by improved management of the processes provided within intermodal terminals.

According to specialists, one of the most logical and at the same time feasible solutions to the outlined problem is the introduction of a comprehensive solution through a single digital platform. The objective is to provide, in real time, the information available to all operators, that is, all interested organisations that perform operations within the logistics intermodal transport centres.

According to the opinion of a large part of the interviewees, at present, it is often necessary to duplicate information; some of the information is also on paper, and schedules have to be updated manually, which is a prerequisite for making errors, as a result of which the time of the cargo's stay increases. Simultaneously, this creates tension among all participating operators, which can be easily avoided by introducing a centralised, unified platform that monitors cargo movement across all modes of transport and intermodal terminals in real time. Therefore, specialists have pointed out that full digital integration, rather than merely the presence of separate systems, would have the greatest immediate effect.

A second leading group of proposals focuses on enhancing communication and coordination among operators.

According to the interviewees, in many cases, no clearly defined “coordination centre” or role manages cargo flows and maintains up-to-date schedules between modes. When a shipment is delayed or equipment is temporarily unavailable, the “domino” effect spreads throughout the chain. Some interviewees directly stated that improving coordination could reduce downtime, even without any physical investment.

The third area is improving operational planning and capacity management. Some respondents emphasised that terminals often “react” to load rather than anticipate it. The introduction of cargo flow forecasting, advanced booking of terminal time slots, and dynamic equipment planning is considered a key mechanism for optimisation. The interviewed specialists agreed that the most significant improvement was not primarily related to infrastructure but rather to its management. The focus of development should be as follows:

- Integrated digital systems.
- Clear coordination channels.
- Preventive operational planning.

The efficiency of intermodal terminals starts not with the cranes, but with the data.

Question 4: What are the most common communication problems between the different actors in the intermodal process?

The answers from the interviewed specialists indicate that communication problems in intermodal transport are not due to a lack of contact between the actors, but rather to a lack of a clear structure and coordination mechanism. Most respondents share that communication is often carried out “point to point” (e.g., terminal ↔ carrier, or freight forwarder ↔ customer), rather than being centralised and transparent for all parties involved in the process.

This way of structuring the communication process logically leads to the loss of some information, data fragmentation, and different versions of problem situations arising from the different perspectives of the parties involved. One of the problems outlined by the interviewed specialists was the lack of coherence or discrepancy in the schedules, affecting three key parties: the railway operators; the road carriers; and the teams at the terminals.

The lack of automated notifications to all parties in the chain leads to delays that are automatically transferred to the next operators in the logistics chain. Some of the interviewees described this as a major synchronisation problem, as everyone waits for someone else to confirm before taking action in turn.

Another common problem identified is the need to duplicate information on various documents, especially those related to customs and forwarding. Some of the interviewees shared that, very often, to continue the movement of goods, they were forced to send the same data through multiple channels, such as by phone, via various internal systems, and Excel spreadsheets. This undoubtedly increases the likelihood of errors and the accumulation of time delays, as well as unnecessary tension between responsible institutions and transport operators. This problem remains particularly pronounced in international cargo transport, which requires complex logistics and multiple parties along the transport chain.

Finally, a significant number of interviewees explained that they were forced to use “personal contacts” to resolve a problematic situation, which was directly related to the lack of a sufficiently transparent information system that could be traced in real time by all interested parties. This informal knowledge is practical in the short term, but cannot be scaled and becomes risky as volumes increase or staff change. The concern is not a lack of communication, but rather the absence of a standard system that enables structured, synchronised, and shared communication among all parties. Therefore, for improvement, “more communication” is not enough; an institutionalised coordination unit or a digital solution is needed that unites the participants around the same information flow. This result directly supports Hypothesis 2, which posits that coordination is a key factor in the effectiveness of intermodal services.

Question 5: What technological or digital solutions do you think would have the greatest impact on reducing downtime?

The experts’ responses outline a consistent trend as the need is not for more technology, but for integrated and interconnected digital systems that enable shared visibility and coordination in real-time.

Most interviewees stressed that currently, the individual actors – terminal operators, rail carriers, transport companies, and freight forwarders – use different software solutions that “do not talk to each other”.

This, in turn, requires additional effort, such as manual data entry, re-entering records multiple times across different software systems used by different operators, and constant phone confirmations to synchronise the operators' actions. According to the interviewees, a possible solution is to use a single digital platform or portal to overcome current inconveniences and problems. At the same time, this platform would provide transparency and traceability regarding:

- Schedules for rail and road transport.
- Currently available resources at the terminal and planned ones.
- Current data on the status and location of containers.
- Information on ongoing and completed administrative procedures related to the required documentation and customs procedures.

Such specialised software, in addition to guaranteeing full traceability and transparency for all interested and responsible organisations (including ensuring everyone sees the same data in real time), would allow for much more accurate planning, including revisions to individual slots, notifications when data are updated, and changes to the schedule. All of the above would enable a better and more coordinated response to unexpected situations, including delays.

Some of the interviewees believed that switching to standardised electronic documents, including electronic consignment notes (e-CMR), would improve service, including faster document flow. Some specialists go even further. They cited foreign intermodal terminals where RFID and automated container recognition enable cargo document processing without delays at entry/exit: HHLA Container Terminal Altenwerder (Hamburg, Germany), DP World London Gateway, Euromax Terminal Rotterdam Cargo, and Beamer Terminal Calais (France). Along with the practice in Europe, the use of such technology in Bulgarian intermodal terminals would significantly reduce errors and optimise cargo processing.

These results directly confirm Hypothesis 1, which posits that digitalisation is one of the most important factors in increasing intermodal terminal efficiency.

Question 6: Give an example of a successfully functioning intermodal terminal (from Bulgaria or abroad). What do you think distinguishes it and makes it effective?

Most of the answers to this question, given by professionals, focus on the European experience in building and managing intermodal hubs, which are known and appreciated for their exceptionally high levels of automation and comprehensive digitalisation. The examples mentioned are related to the intermodal terminals in Rotterdam, Duisburg, Budapest, and Constanta, and, in the Bulgarian context, the intermodal terminal in Plovdiv (as a step in a positive direction, but not yet with a fully operational business model).

According to most interviewed specialists, the common aspect of a successful terminal is, first of all, centralised coordination and, as a result, a clear distribution of roles among the participating organisations. According to a generalised understanding, a successful terminal is not only a place where various cargoes are processed. The professionals' view is more related to the much more important role of the intermodal terminal as a coordination centre, through which the entire logistics transport is managed in real time. This should lead to good planning by all participating organisations, including improved capacity utilisation of the intermodal terminal itself. This would also minimise downtime and improve synchronisation and trust between operators.

An important characteristic of successful hubs is the presence of an integrated information system that provides all operators with a single operational picture in real time. As has already been emphasised several times, this will lead to better coherence in actions, avoiding errors and the duplication of information required for entry into several parallel systems, as well as unnecessary checks, manual entry, and verbal reconciliation of the data. According to many interviewees, if the system works successfully, it will allow information to “travel” faster than cargo, enabling logistics planning before the physical movement.

The next main element that deserves to be highlighted is the automated handling of cargo, which includes various components: the use of automatic cranes, container recognition systems (OCR/RFID), and advanced time-slot booking. According to the interviewees, automation significantly reduces reliance on the human factor while simultaneously making processes more predictable, transparent, and clear. An additional significant aspect is the reduction of administrative burden and the potential for the emergence of corrupt practices.

The analysis of interviews with seven professionals in the field of intermodal transport and intermodal terminals yields a relatively uniform general perspective on development. This is related to the geographical location and the existing international transport corridors. However, digital development and increased automation in cargo management would lead to significant improvements in the quality of intermodal services.

Almost all interviews emphasise that the most significant improvement with a tangible effect is related to digital integration, not just the introduction of software. The creation of a single information and coordination platform that would provide data to all interested organisations in real time is undoubtedly a necessary and inevitable step. The lack of sufficient coordination and synchronisation, as evidenced by poor communication between the different operators, the accumulation of tension, and mutual accusations in the event of a problematic situation, has the potential to be perceived as the main barrier to achieving the efficiency of the intermodal terminal.

The responses indicate that successful examples from abroad are distinguished not by the scale of the infrastructure, but by the organisation and digital management of flows, which make processes predictable and controllable. This means that the path to development in Bulgaria is achievable and not associated with significant capital investments, but rather with targeted changes in management, coordination, and information exchange. Interviews revealed that intermodal efficiency entails increased connectivity, transparency, and a unified logistical framework among operators.

5. Discussion.

The results of the analysis indicate that the efficiency of intermodal terminals in Bulgaria is insufficient and is not solely due to the lack of basic infrastructure. Along with improving infrastructure, equally serious work should be done on the organisational and operational factors determining the efficiency of business processes and operations performed in the terminals. It is important to note that the existing terminals are already integrated into the TEN-T network, as well as that there is a clear strategic and political vision for their long-term development, including ways to secure financing for infrastructure modernisation (approved and effective strategic documents and implementation of projects under operational programs financed by European funds).

At the same time, however, the lowest values of estimated efficiency are attributed to the lack of good coordination between the various participants and the duration of cargo detention. This result leads to the justified conclusion that the performance of intermodal terminals depends not only on the built infrastructure (as a basic condition) but also on the quality of the processes performed.

This reflects the quality of interactions among various operators, carriers, and logistics intermediaries. In this sense, digitalisation is recognised as a key factor that can lead to an increase in the efficiency of operations and processes performed at terminals. The results clearly show that a higher level of digitalisation and digital integration of systems leads to better coordination and a shorter time required for cargo processing. This, in turn, provides a clear indication of the possibilities for enhancing operational efficiency. The specificity of digital tools enables real-time exchange of information. This, in turn, leads to increased transparency in the logistics chain and a reduction in uncertainty during the planning and implementation of transport operations. It should also be noted that digitalisation is an essential, yet insufficient, condition for improving efficiency. Digitalisation must be consistently implemented, inclusive, and accepted in the daily work of all participants involved in various intermodal operations.

Coordination among stakeholders is crucial to achieving high efficiency at intermodal terminals. The observed relationship between low levels of coordination and longer delays in cargo movement highlights the importance of coordination capabilities and the full utilisation of management mechanisms and integrated operational processes.

This result underlines the conclusions drawn in the specialised literature, which focuses on the capabilities of network management, coordination efforts, and institutional coherence in intermodal systems. The insufficient coordination among various stakeholders and all participants in intermodal transport can neutralise its main advantages, even with modern, relevant infrastructure and potential technological solutions.

From a practical perspective, the study's results highlight the need for a more holistic approach to the development of intermodal transport, particularly at intermodal terminals. In this sense, investments aimed at expanding terminal infrastructure and capacity are a fundamental element, but they cannot lead to significant improvements in efficiency.

A much more complex approach should be taken, and infrastructure projects and efforts to expand, modernise, and develop terminals must be combined with measures to improve coordination and digital integrity. For logistics operators, this may require implementing shared digital platforms, harmonised data exchange standards, and joint planning practices. From a public policy perspective, the results support national and European strategies that emphasise digitalisation, interoperability, and coordination among actors as essential tools for promoting intermodal transport and achieving a modal shift towards more sustainable freight transport.

6. Conclusions.

The level of development and overall operation of intermodal terminals in Bulgaria. Overall, the data indicate an average level of terminal efficiency, which, according to the respondents, is attributed to poor coordination among the various participants responsible for the chain, resulting in longer cargo dwell time.

Infrastructural constraints are also important, but they remain relatively in the background, overshadowed by the partial implementation of digitalisation and the lack of comprehensive digital solutions. Proper and skilful integrated information management, especially given the country's strategic geographic location, will lead to rapid improvement in the overall efficiency of intermodal terminals.

In the course of the study, the initially developed hypotheses were confirmed, namely, a higher level of digitalisation will increase the efficiency of intermodal terminals in the country; more skilful coordination between the various stakeholders will lead to shorter goods dwell times at the terminals; and the main limitations to the full development of intermodal terminals are related to the quality of infrastructure and the lack of sufficient organisational and managerial capacity.

The main limitations of this study are the small sample size (32 respondents) and the purposive sampling used to recruit participants (i.e., lack of randomness). Simultaneously, the limitation is also related to the territorial scope (the data refer only to Bulgaria). Digital integration is emerging as more strategically important for the current development of intermodal terminals than traditional infrastructure.

A single digital system/platform is recommended to improve information exchange, coordination among participants in the logistics process, and integration among operators. Standardisation of e-CRM documents and the use of full automation capabilities (OCR, RFID, and TOS integration) are also recommended.

The following recommendations can be addressed to managers of intermodal terminals to improve their efficiency significantly. First, introduce a single digital data exchange platform. This platform provides all available information related to reservations, schedules, additional specific documents, and cargo status.

Second, to standardise operational procedures (clear time slots, rules for reception and dispatch), necessary accompanying documents, and complete document flow.

Subsequently, it is beneficial to consider a coordinator responsible for synchronising the activities between the different railway operators, carriers, and forwarders. Active dwell time management should also be introduced, which should include the analysis of the so-called bottlenecks, continuous monitoring, and tracking of KPIs.

Finally, it is necessary to allocate time and resources to train staff and partners involved in intermodal processes to work with digital systems and coordination protocols.

Conflict of Interest Statement.

The authors declare that there is no conflict of interest.

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