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A Conceptual Framework for Developing Intelligent Services (a Platform) for Transport Enterprises: The Designation of Key Drivers for Action

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Abstract: In the digital era, effective business management relies on dynamic risk analysis and real-time data integration, particularly amid the evolving landscape shaped by technological advancements and external factors such as climate change and global health crises. This study delves into the specific demands for digital services within the transportation sector, focusing on the crucial task of identifying an optimal data-driven management system (platform) to bolster transportation decision-making processes. The paper revolves around the formulation of a comprehensive conceptual framework for the development of intelligent services and platforms tailored explicitly to transport enterprises. Methodologically, a thorough analysis of critical infrastructure-related challenges was conducted, emphasizing the integration of a service-oriented approach to enhance overall functionality. Central to the paper's approach is the careful navigation of conflicting user requirements, resource constraints, and the imperative of maintaining adaptability in service implementation. Additionally, a robust data flow analysis framework is presented, encompassing data collection, model building, and model extrapolation, which enables the generation of reliable outputs essential for informed decision-making. Notably, the study underscores the pivotal role played by the EN.I.R.I.S.S.T. research infrastructure in delivering essential services to the transportation domain, offering accessible data, user-friendly interfaces, and data analysis tools. The findings highlight the enthusiastic reception of the diverse services among potential users, indicating a strong willingness to engage and benefit from the proposed solutions. By emphasizing the integration of intelligent services, the paper seeks to present a systematic approach aimed at enhancing the efficiency, productivity, and competitive edge of transport enterprises through the strategic deployment of advanced technological solutions and proactive planning. This paper ultimately contributes cutting-edge research insights, empowering transportation managers, planners, and decision-makers with valuable resources for informed business intelligence and corporate strategy.

Keywords: intelligent services infrastructure; data-driven decision-making; intelligent tools; evaluation of needs; sectorial prioritization for implementing intelligent tools; conceptual architecture

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1. Introduction

In the current digital age, the transportation sector faces multifaceted challenges that necessitate a sophisticated understanding of complex data interactions, technological advancements, and dynamic risk assessments. As one of the key drivers of economic growth and societal development, the transportation sector operates within a highly competitive and ever-evolving environment, where the efficient movement of goods and people across national and international borders is crucial. To ensure seamless operations, it is imperative to harness cutting-edge technologies and intelligent infrastructure solutions that facilitate informed decision-making, enhance operational efficiency, and improve overall organizational performance.

Against this backdrop, the Intelligent Research Infrastructure for Shipping, Supply Chain, Transport, and Logistics (EN.I.R.I.S.S.T.) project has emerged as a transformative initiative aimed at addressing critical research gaps within the transportation landscape in Greece. Comprising a consortium of 11 partners, including educational institutions, research centers, industry representatives, private companies, and policymakers, EN.I.R.I.S.S.T. seeks to establish a center of excellence dedicated to fostering research, innovation, and strategic development in the transportation sector.

To comprehensively address the challenges faced by the transportation sector, this paper is dedicated to delineating the specific requirements for the development of a data-driven management system. By leveraging an in-depth analysis of the sector's demands, the paper aims to offer a robust conceptual framework tailored to the distinctive needs of transport enterprises. The methodology employed emphasizes an integrated service-oriented approach, taking into account diverse stakeholder perspectives, resource constraints, and the imperative for adaptable service implementation. Additionally, the paper outlines a comprehensive data flow analysis framework that encompasses data collection, model development, and reliable output generation to facilitate effective decision-making processes. This paper not only delves into the key objectives surrounding the definition of the requirements for this platform but also emphasizes the significance of the survey conducted (Section 3.3), which plays a pivotal role in gauging the specific needs and preferences of stakeholders within the transportation domain, thus underlining the centrality of this research component.

The subsequent sections of the paper delve into the critical aspects of background research and literature, followed by an exploration of the study's methodological background, application, and concluding insights. With a primary focus on outlining the requirements for a data-driven management system and its applicability in enhancing business intelligence services within the transportation sector, the paper underscores its contribution to advancing the field's research and innovative infrastructure.

2. Background Research and Literature

This section serves as a foundational exploration of key aspects influencing the development of research infrastructure (RI) objectives within the transportation sector. Section 2.1 delves into the specific goals and functions of RI, highlighting its crucial role in supporting the complex operational landscape of the transportation industry. Building upon this, Section 2.2 investigates the contributions of intelligent infrastructure to research and innovation, emphasizing the transformative impact of advanced technological solutions on the sector's overall efficiency and resilience. Furthermore, Section 2.3 critically examines the various challenges and technological imperatives that have emerged within the ever-evolving transportation environment, shedding light on the intricate interplay between digital advancements and industry demands. Lastly, Section 2.4 presents an insightful overview of the EN.I.R.I.S.S.T. project, emphasizing its pioneering initiatives and strategic objectives in bridging critical research gaps within the transportation domain. Through an in-depth analysis of these interconnected themes, this section aims to provide a comprehensive understanding of the contextual backdrop that underpins the subsequent discussions and analyses within this paper.

2.1. Research Infrastructure (RI) Objectives

For as long as organizations have been operating, forecasting, and conducting scenario analysis, they have been required to do so within the business ecosystem in which they act, operate, and regulate change [1]. This has been particularly the case in recent years, with technological innovation and circumstances such as climate change and epidemics acting as catalysts for functional changes in market structures, management structures, and service levels [2]. In particular, the term "business resilience" refers to more than just financial performance in today's businesses; it also refers to the internalization of risks caused by external factors affecting the current state of the business world [3,4]. The

impact of these factors on the business ecosystem establishes a baseline for risk assessment, thereby encouraging the development of new areas of strategic and business planning in the context of operational contingency, product line continuity, and financial productivity, among other things.

As a result of their inability to adapt quickly to changing conditions and develop plans to mitigate future risks, or more specifically, because they lack the capacity to accurately forecast the future, companies in this sector are driven to extinction and labeled as unresilient, according to a report by the World Economic Forum [5,6]. A critical driver of the development of Intelligent Transportation Facilities in this context is improving the accuracy of forecasting prospective developments over medium- and long-term horizons. A combination of growing complexities in the world's international business environment and a worldwide increase in demand for transportation services has led to unprecedented levels of capital investment to meet said growing demand. Despite the fact that these systems generate massive amounts of data, there is an overwhelming need to extract accurate, valuable, and useful information from the data produced by these systems, which is a demanding task on multiple levels [7].

It is critical for the transportation sector ecosystem to have a research infrastructure because it allows for better planning, management, and decision-making in order to adapt to new conditions in the future, for which knowledge remains largely limited. Furthermore, business analytics are required across all functional lines and across all types of organizations, including government agencies [4]. Accurate data are required for scenario planning in areas such as master and business planning, financial and marketing planning and management, human resource planning and management, and manufacturing planning, spanning the transportation sector, from small business units to large multinational corporations and national organizations [8]. Researchers' institutes must be viewed as long-term strategic investments at all levels of society with roots that run deep and ultimately weave into the fabric of the community. They must be recognized as essential for enabling and developing excellence in their respective scientific fields, as well as key players in a very wide spectrum/playing field of competitiveness. No matter what size or scientific focus a research infrastructure has, the long-term benefits it provides to society are undeniably significant [9].

2.2. Intelligent Infrastructure Contribution to Research and Innovation

The process of intelligent infrastructure development involves embedding sensing, computing, and communication capabilities into traditional urban and rural physical infrastructures such as roads, buildings, and bridges in order to increase efficiency, resiliency, and safety. Because of the installation of controllers, intersection scheduling mechanisms, and sensors along roads, for example, new capabilities in traffic signal control and traffic flow optimization can be developed and tested. It is possible to improve energy generation and transmission efficiency, as well as their resilience to natural and human-caused disruptions, through the development of intelligent power grids. The integration of new energy sources such as wind and solar can also become more straightforward [3].

Intelligent infrastructure has the potential to significantly improve operational performance because of its ability to guide improvement efforts through decision support. Various topics, ranging from automation to the distribution (?) of generalized knowledge over a long period of time, are covered by these "loops" or cycles of learning. Advancements in transportation systems can provide decision support for the proactive management of special circumstances (such as disaster responses), assist in the planning and prioritization of new road/control modifications, and ultimately document generalized knowledge that can be applied across multiple cities with varying transportation systems.

One of the most difficult challenges in developing integrated intelligent tools for the transportation sector is dealing with the unexpected and significant shift in economic output that can occur as a result of unforeseen events. Developing integrated intelligent tools for the transportation sector is a major challenge, and it is one of the most difficult challenges

to overcome [10]. For example, fluctuations in oil and energy prices, spikes in inflation, currency rates, mobility restrictions, and border/visa policies can all have an impact on demand in small or large regions, and in some cases, entire economic systems, as was the case for the Eurozone during the COVID-19 pandemic in the early 2020s. Specifically, "intelligence" refers to the process of utilizing massive amounts of data (megadata) in order to (a) forecast future levels of demand or economic output (revenues, prices, and so on), (b) assess risks and business resilience, and (c) provide accurate data to support decision-making.

2.3. Challenges and Technological Imperatives in the Evolving Transportation Landscape

The transportation sector is currently grappling with complex challenges that necessitate a powerful technological paradigm to address its evolving landscape. Issues such as increasing digital connectivity, infrastructure vulnerabilities, and the imperative to improve carbon efficiency in operations have amplified the need for sophisticated, data-driven platforms and digital services [11–13]. With the proliferation of advanced technologies, including the Internet of Things (IoT) and artificial intelligence (AI), the transportation sector has witnessed a transformational shift in the way infrastructure is managed and operations are optimized [11].

Furthermore, the contemporary transportation environment is characterized by a surge in demand for seamless and efficient logistics solutions, underscoring the criticality of intelligent data management systems and agile operational frameworks [14,15]. The rise in urbanization and the consequent challenges of congestion, coupled with the increased pressure on existing transportation networks, have accentuated the need for comprehensive digital solutions tailored to the specific demands of the sector [9,16].

To this end, our research endeavors to elucidate the intricate requirements for developing data-driven platforms and digital services attuned to the contemporary challenges within the transportation sector. By delving into critical aspects, such as event observation, socioeconomic impact assessment, market trends, and demand forecasting, our study aims to address the pressing needs of supply chain operators and diverse business entities operating within the transportation domain [12,13,17]. With an emphasis on resilience, sustainability, and efficiency, our work seeks to contribute to the overarching goal of fostering a technologically advanced and future-ready transportation ecosystem [11,17].

2.4. EN.I.R.I.S.S.T. Project Overview

The "Intelligent Research Infrastructure for Shipping, Supply Chain, Transport and Logistics" (EN.I.R.I.S.S.T.) is a unique and pioneering research infrastructure that aims to fill a significant existing research gap in the fields of shipping, supply chains, and transport in Greece. It combines the collection and processing of data (with the intent of protecting privacy and copyright), the development of innovative models and programming techniques, the development of useful, secure, and user-friendly applications, and finally the establishment of digital observatories aimed at supporting public and private stakeholders (businesses, public bodies, research organizations, etc.) [18]. In this way, the vision of EN.I.R.I.S.S.T. is to become a center of excellence that will promote and support research in various scientific fields. The objectives of EN.I.R.I.S.S.T. are as follows:

- To create an intelligent research and business platform to support critical economic activities and small and medium-sized businesses operating in areas of interest for research infrastructure;
- To collect and process data on national and international passenger and freight transport, including sea, air, inland, and intermodal transport, and provide researchers and users with information and tools;
- To assist stakeholders in the development of original research, investment plans, and policies (academic community, researchers, infrastructure operators, private and public companies, and policymakers);

- To establish a multi-faceted institution of economic and research development for Greece, by constructing new networks and enhancing existing ones, to facilitate the flow of knowledge and information.

The intelligent research infrastructure EN.I.R.I.S.S.T. is composed of 11 partners, which include 8 educational institutions and 3 research centers in Greece. Within the EN.I.R.I.S.S.T. infrastructure, researchers specialized in shipping, supply chains, and transportation, as well as software developers, join forces and bring together their expertise. This specialization promotes research excellence and ensures an integrated approach to the challenges of the above sectors, leading to successful implementations of the infrastructure. In addition to the major partners, the EN.I.R.I.S.S.T. infrastructure ecosystem is made up of industry representatives, private companies, public enterprises, policymakers, independent researchers, and citizens.

3. Proposed Methodology

In this section, the proposed methodology is delineated, encompassing a comprehensive elucidation of the key analytical frameworks employed in the development of intelligent research infrastructure for the transportation sector. Section 3.1 delves into the conceptual architecture, providing a detailed examination of the foundational elements and design principles underlying the proposed intelligent services platform. Building upon this, Section 3.2 offers a comprehensive analysis of the data flow analysis framework, emphasizing the crucial role of precise data collection, model building, and model extrapolation in ensuring the generation of reliable outputs for effective decision-making. Additionally, Section 3.3 provides an in-depth exploration of the survey results analysis framework, meticulously quantifying the analysis of questionnaire data using various statistical parameters. These statistical parameters have been instrumental in discerning the respondents' perspectives and refining the research infrastructure's proposed services. Through a meticulous examination of these sub-sections, this paper aims to establish a robust methodological framework that underpins the development of a sophisticated and responsive digital platform for the transportation sector.

Within the scope of the paper's methodological framework, the incorporation of a comprehensive data flow analysis approach is further enriched by a complementary investigative survey strategically designed to capture the nuanced requirements of potential users. By holistically integrating the findings of this survey into the foundational fabric of the methodology, the paper discerns and prioritizes the specific needs and preferences of stakeholders within the transport sector. Leveraging this crucial understanding, the paper's focus is directed towards the development of EN.I.R.I.S.S.T digital services, meticulously tailored to cater to the identified demands of the transportation industry. Through this holistic amalgamation of a robust data flow analysis framework and an insightful survey, the methodology exemplifies a nuanced and proactive approach, delineating a novel pathway for the development of intelligent services and platforms within the transport domain.

3.1. Conceptual Architecture

During the architectural design process, critical issues related to the development and operation of the infrastructure were addressed. Many of the requirements of the users were found to be conflicting, and the available resources were limited. A service-oriented approach was proposed for infrastructure development. According to this approach, each functional unit is implemented as a service, which is integrated into a platform that will contain a set of different services, and which communicates in a predetermined way with the rest of the components.

A mechanism is required to maintain flexibility in the design of the architecture, i.e., to be able to add and remove services without significantly increasing the computational cost. It was noted that the services of the various platforms would be developed simultaneously/in parallel to one another. In order for EN.I.R.I.S.S.T. to provide new opportunities in its areas of activity, wherein complex economic, social, and technological processes take

place, it was required that the following elements be taken into consideration in the design of its architecture:

- The size of the data that its platforms have to manage;
- The volume of calculations performed by each service's procedures;
- The complexity of the procedures carried out in the context of its services;
- All current technological and business trends.

In general, the research infrastructure will use multiple data sources and a set of new methods that process and analyze data from these data sources. It, therefore, made sense for its applications to have high data requirements. This has a decisive influence on EN.I.R.I.S.S.T's development and conservation strategy. Based on the above, it appears that EN.I.R.I.S.S.T. will integrate a large number of applications, which will provide useful services to research centers and companies. A wide variety of technologies will be used to implement them, which attests to the inherent complexity of the systems and services involved in data analysis. In fact, their complexity increases as they develop and expand.

The presentation of the architecture begins with the use cases that the infrastructure system is equipped to support, followed by the consolidation of the necessary elements at the functional level. Based on the usage scenarios, the cases of using the system were determined. The sequences of actions required to fulfill the usage scenarios were identified, while at the same time, the independent functions that are combined to form a use case were provided in an abstract way. These instances of system usage indicate the degree of complexity and the need for communication and orchestration of the various elements that will be integrated into the EN.I.R.I.S.S.T. infrastructure. The proposed architectural approach aims to cover all complex scenarios of use of the RI while ensuring great flexibility in the processes of system expansion and modification.

The EN.I.R.I.S.S.T research infrastructure will implement and provide a number of platforms for shipping, supply chains, and transport: (a) the ecomarine platform, (b) the maritime heritage platform, (c) the passenger platform, (d) the infrastructure platform, (e) the inland and intermodal freight platform, and (f) a decision support tool for shipping and financial markets. Each platform aims to make available a set of data and web services (with the most user-friendly interfaces possible) and data analysis tools/processes. These services aim to provide data access, as well as to assist both researchers and companies in devising new strategies through their analysis, with the objective of becoming more competitive. In order to be able to do this, it is necessary to somehow record the needs of the RI's potential users and, subsequently, to form some user groups.

The presentation of the research infrastructure architecture followed a logical path that started from the supported use cases and proceeded to its functional parts at a conceptual level. The architecture must be scalable and flexible to modifications. In order for the architecture design to be successful, it must address the following considerations:

- Ease of use;
- Efficiency;
- Security;
- Scalability;
- Reliability;
- Maintenance.

3.2. Data Flow Analysis Framework

When selecting an analysis methodological framework, the most important consideration to keep in mind is that the results must be useful to organizational managers in their decision-making process. The most important requirement is that the analysis outputs are understandable and reasonable for users to understand. Therefore, analysis outputs should be accurate, timely, and easily comprehensible to users in order to be used for improved decision-making in their respective fields.

The understanding that any analysis techniques operate on data generated via historical events and situations led to the identification of the following three steps in the process of developing an infrastructure architectural design (Figure 1):

- Data collection (the development of a database)

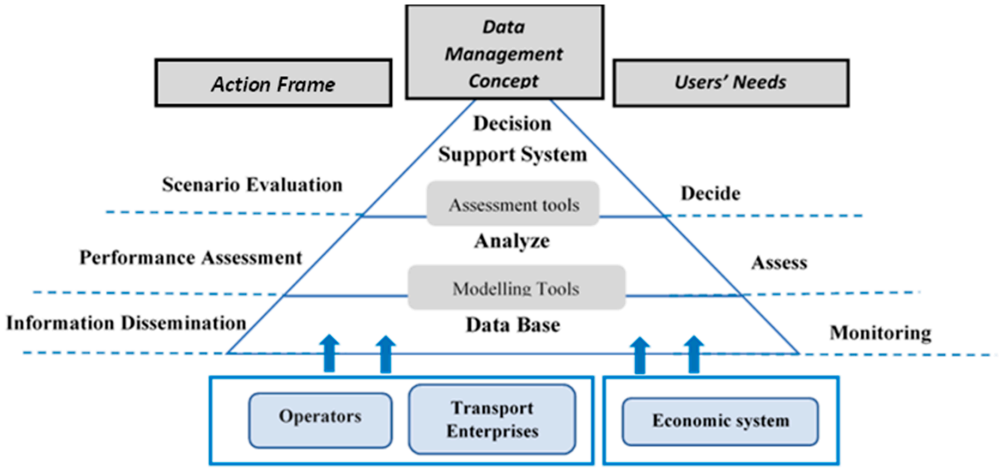

Figure 1. Data inflow and analysis levels for developing RI services.

This category included data collection from operators, transportation enterprises, and the economic system, pertaining to demand (traffic), socioeconomic characteristics, and operational characteristics (capacity), among other things. There was an insistence on the importance of obtaining the appropriate data and ensuring that they were used when they were called for since, oftentimes, subsequent steps can be performed on data that are irrelevant to the current problem. This is frequently the most challenging step in the entire RI development process, as well as the most difficult step to monitor. The collection of relevant data within an organization is always fraught with difficulties, as is the quality control of the data collected.

- Model building (the creation of a metadata warehouse)

In order to develop key performance indicators and forecasting, this position analyzes incoming data using quantitative methods and modeling analysis tools. To construct a model, it was necessary to fit the collected data into a variety of quantitative models that produced a variety of outcomes. Often, a balance needs to be struck between employing a sophisticated modeling framework that provides slightly greater accuracy and adopting a straightforward approach that is easily understood and gains user acceptance and approval. Clearly, this selection process requires a certain level of judgment.

- Model extrapolation (service outputs and the interface)

The actual modeling extrapolation that takes place after the data have been collected, stored, and tested is referred to as the actual modeling extrapolation. The accuracy of the process was checked on a regular basis for recent periods for which actual values are known. The development of an intelligent decision support system lay at the heart of the project (DSS).

An analysis of the existing literature revealed a multitude of methodologies employed for data-driven management systems in the transportation sector. Various studies have emphasized the significance of data collection, analysis, and interpretation in decision-making processes for optimizing transportation operations [19]. The current literature has primarily focused on traditional data analysis frameworks, which often lack the comprehensive integration of dynamic real-time data and practical decision support [20].

Furthermore, the existing approaches tend to underscore the technical aspects of data collection and analysis without adequately addressing the crucial requirements for effective utilization by managers and stakeholders [21]. This gap highlights the need for a more

user-centric approach that aligns the technical accuracy of data outputs with the practical decision-making needs of transportation industry professionals [22].

The proposed framework in this paper introduces a novel data flow analysis methodology that not only prioritizes accurate data collection and modeling but also emphasizes the user-friendly presentation of the results. By incorporating elements such as descriptive, prescriptive, predictive, and planful capabilities, the proposed workflow surpasses traditional models in its ability to provide comprehensive, actionable insights for decision-makers. The framework's emphasis on effective decision support and user accessibility represents a notable advancement over the existing literature and holds the potential to significantly enhance the efficiency and competitiveness of the transportation sector [23].

This section discusses the context and methodology used to ascertain the needs of RI's potential users. The stages of the research process were as follows [24,25]: The objective was to correlate user questions and responses in order to draw useful conclusions during the architecture design phase, data mining (primary, secondary, or metadata), and development of the proposed system within the specific research infrastructure. Exploring the needs of potential users was not a standard process, on the one hand because no services were being implemented for the time being, and on the other hand because the scope and scale of the analysis, which could be accomplished either by identifying needs or by examining the utility in the development of RI's proposed services, were not standard. Taking into account the dynamic market characteristics, as well as the highly competitive environment, the methodological approach followed four distinct stages. The main stages of the present research process for the identification of needs and requirements in transport activities are shown in Figure 2.

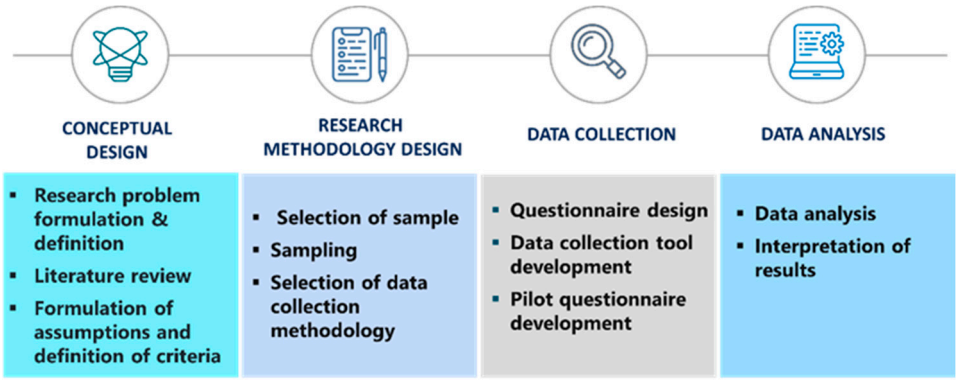

Figure 2. Main stages of questionnaire-based research methodology development.

3.3. Survey Results Analysis Framework

The analysis of questions is sufficiently quantified by a sufficient number of statistical parameters, which are distinguished by the significant extraction of internal information for the collected data [26,27]. The statistical parameters selected for the analysis of the questionnaire were as follows.

- Response Rate 1 (R1): The number of people who answered the electronic questionnaire, divided by the number of people in the sample. It was expressed in the form of a percentage;
- Response Rate 2 (R2): The number of people who answered the on-site questionnaire, divided by the number of people in the sample. It was expressed in the form of a percentage;
- Variation (var): The expected value of the square deviation of the random variable from the mean value. It measured how far the score of each criterion, in terms of meeting the needs of the RI's users, extended from its mean value.

$$var = \frac{1}{N-1} x \sum_{i=1}^{N} (x - \overline{x})^2 \quad (1)$$

where x = the criterion rating and N = the number of criteria

Generally, variation is calculated by taking the differences between each number in the data set and the mean, then squaring the differences to make them positive, and finally dividing the sum of the squares by the number of values in the data set.

The fluctuation shows us how far (or close) from the average value, the other values are. When prices are far from average, the fluctuation is large. But when prices are close to average, the fluctuation is small (var $\in$ [0, 1]).

The following assumptions were made in our analysis:

- When var < 0.6, (a) the question is normally defined and (b) the dispersion of the answers determines the result (value) in a very satisfactory way;
- When var > 0.6, a recheck is required (a) to see if the question was understood by the sample and/or (b) to account for the great dispersion of values in the answers;
- Standard deviation (σ) is used to calculate the amount of change or scatter of a set of data values. In this analysis, it was used to reflect the amount of change or scatter of the mean score of each criterion to meet the needs of the RI's users. The standard deviation was calculated as the square root of variance by determining each data point's deviation relative to the mean.

$$\sigma = \sqrt{\frac{1}{N-1} x \sum_{i=1}^{N} (x - \overline{x})^2} \quad (2)$$

where x = the criterion rating and N = the number of criteria

A low standard deviation indicates that the data points tended to be close to the average of the criteria (the expected value) of the set and were concentrated around the average, while a high standard deviation indicates that the data were scattered over a wider range of prices and moved away from the average price.

Standard deviations were also used to measure confidence in statistical results. The margin of error was determined by calculating the expected standard deviation in the results and determining whether the questionnaire had to be conducted multiple times. This derivation of the standard deviation is often referred to as the "standard error" of the estimate or the "standard error of the mean". The reported margin of error in the questionnaire was calculated from the standard mean error (or, alternatively, the product of the standard population deviation and the inverse of the square root of the sample size) and was typically about twice the standard deviation.

- When σ < 0.5, the reported margin of error in the questionnaire was too small, and the results had a very high degree of reliability;
- When 0.5 < σ < 1.0, the reported margin of error in the questionnaire was within the acceptable limits, and the results had a satisfactory degree of reliability;
- When σ > 1.0, the reported margin of error in the questionnaire was wide, and the results had a low degree of reliability.

It is emphasized that the above were calculated with a confidence interval of 95% in the answers of the sample.

4. Investigatory Survey Approach

This section offers a comprehensive exploration of the investigatory survey approach, focusing on the pivotal role it played in gathering data on the needs and requirements of potential users within the transport sector in Greece. By emphasizing the centrality of the survey in understanding the specific demands and preferences of the sector's stakeholders, Section 4.1 provides an insightful analysis of the transport sector's contributions, considering its significance in shaping the overall economic landscape of Greece. Furthermore, Section 4.2 delineates the key features of the questionnaire, highlighting its targeted design aimed at capturing the nuanced needs of potential users regarding the offered services. The subsequent Section 4.3 presents a detailed overview of the preliminary results derived from the survey, shedding light on the prioritization of user needs and how these findings

informed the development of the EN.I.R.I.S.S.T digital services within the transport sector. By elucidating the survey's crucial role in shaping the platform's service offerings, this section aims to underscore the critical importance of user-centric research and its implications for the evolution of the research infrastructure in the Greek transport sector.

4.1. The Contribution of the Transport Sector in Greece

The Mediterranean region is one of the world's most desirable tourist destinations, accounting for roughly a third of ITA [28]. For decades, Mediterranean destinations have provided traditional sun, sand, and sea products, primarily to Northern European markets. Although the northern segment of the Mediterranean tourism market is much more developed, a recent widespread development in the southern segment has occurred [29]. In 2018, travel and tourism contributed 20.6% of Greece's GDP. Though the contribution from travel and tourism to Greece's GDP (% of GDP) has fluctuated significantly in recent years, it generally increased from 1999 to 2018, reaching 20.6% in 2018.

The completion of the national transportation system, with a particular emphasis on trans-European corridors, in order to improve accessibility throughout the country and to establish Greece as a major transport hub for the Eastern Mediterranean, has been a major objective and the driving force behind relevant funding. Marine transport also plays a significant role in the Greek transport mix, owing to the country's geographical location. Greece has 889 ports (commercial, tourist, fishing, or mixed), of which 138 are considered major ports. However, many of these ports still require significant infrastructure upgrades to handle the summer months' peak loads [30].

Transport volumes, for both passengers and freight, have increased significantly and steadily over the last decade. In addition, road transportation, particularly private automobiles, has seen an increase in its share of the modal split. Approximately 40 million tonnes of goods pass through Greek ports each year; pipeline transportation has more than quadrupled in the country since 2002. Additionally, logistics is a strategic sector with significant potential for growth in the Greek economy. Considering the country's geographic location, this is an inevitable result. Located at the southernmost point of continental Europe, Greece has a strategic location adjacent to one of the world's three major intercontinental shipping routes [31,32]. Consequently, through its ports (primarily Piraeus and Thessaloniki), road and rail networks, storage and air transport facilities, and associated logistics services, Greece has the potential to serve as a regional or even European hub for transshipment and connectivity.

4.2. The Questionnaire's Key Features

The conducted survey was meticulously designed to reveal and prioritize the diverse needs and preferences of potential users, serving as a crucial step in the development of the EN.I.R.I.S.S.T. Research Infrastructure. With a primary focus on understanding the intricate requirements of stakeholders in the transportation sector, the survey's overarching goal was to capture essential insights that would directly inform the creation of an intelligent and user-centric platform. Spanning a comprehensive sample size of 300 individuals and encompassing nationwide coverage across Greece, the survey gathered critical data through a strategic combination of on-site questionnaires and electronic surveys over an extended period. Employing a simple random sampling method ensured that the survey adequately represented various categories of users, enabling a robust analysis of their distinct expectations and challenges. The use of a well-structured questionnaire, consisting of diverse question formats and rating scales, not only facilitated a nuanced understanding of users' access to data management platforms but also underscored the survey's pivotal role in guiding the development of the infrastructure's intelligent services.

The presented questionnaire outputs suggest several areas for developing tools and applications based on quantitative techniques of data analysis. The level of detail must be considered in the structure and governance framework of each sector. The questionnaire's key features are summarized in Table 1.

Table 1. The questionnaire's key features.

Purpose of the research	Capturing the needs of potential users for the development of the EN.I.R.I.S.S.T. research infrastructure, the goal of external evaluations by users referred not only to the content, efficiency, accessibility, and prospects for improving the research infrastructure design but also to a first investigation of the needs of all actors for data, information, and related tools.
Research objectives	The questionnaire was addressed to organizations that were potential users of the research infrastructure. The categories were selected based on their operating framework, which included shipping, air transport, inland transport, and supply chain operators. The questionnaire research was targeted, and the criteria for the selection of the organizations were the object of action and the spatial coverage of their activities to be compatible with the objects and the area of the research infrastructure. Thus, the sample questionnaire was grouped into the following main categories: A. Public administration ✣ Central government ✣ Local government B. Research ✣ University ✣ Research institute C. Private sector ✣ Transport—logistics infrastructure management ✣ Means of transport operation ✣ IT services ✣ Construction/marketing of equipment or infrastructure ✣ Consultants
Sample size	300 individuals
Geographical coverage	Nationwide (Greece)
Data collection method and period	A. Field research through on-site questionnaires sent to the RI's potential users (October 2019); B. Field research through electronic questionnaires sent to the RI's potential users (November 2019—June 2020).
Sampling method	The sampling method chosen was simple random sampling, which provided each carrier category with the same chance of being included in the sample. To perform simple random sampling, the statistical population data must be recorded in a list (a sampling box). Then, the members of the list were randomly selected until a number equal to the sample size we wished to have had formed. This sampling method ensured the randomness of the sample in terms of the main characteristics and objectives of the research.
Research type	Quantitative survey using a structured questionnaire
Number of questions	The questionnaire consisted of four categories of questions and a total of seven questions. Aa. Organization category; Ab. Governance framework; B. Users' access to data management platforms in the fields of international transport, inland transport, and logistics; C. Ratings of data management platforms development in the fields of international transport, inland transport, and logistics; D. Ratings of the RI's services.
Questions type and rating scale	A. Closed-ended questions (questions 1–5); B. Open-ended questions (question 6); C. Question with dichotomous scales (question 2); D. Multiple choice questions (questions 1 and 4); E. Likert scale questions (questions 3 and 5).

4.3. The Questionnaire's Preliminary Results

In this section, the preliminary results of the questionnaire to determine the needs of potential users of the EN.I.R.I.S.S.T research infrastructure are summarized.

The questionnaire, conducted to determine the requirements of potential users within the transportation sector, yielded crucial insights into the specific needs and preferences of diverse stakeholders. As outlined in the background section, the contemporary transportation landscape is undergoing rapid digital transformation, necessitating tailored data-driven solutions to address the sector's wide-ranging challenges [11,13,17].

Figure 3 shows the distribution of respondents according to the category and governance framework, respectively, of the institution/organization to which they belonged. Regarding the organization categories, most respondents belonged to the higher education sector (62.7% at universities and 12.7% at research institutions). Significantly fewer potential users of the research infrastructure stated that their organization was involved in the management of transport infrastructure and/or logistics (7.20%), that it was a central administration body (7.20%), or that it provided consulting–design services (6.50%). Finally, according to the respondents, a very small percentage of the entities to which they belonged were engaged in the construction/marketing of equipment or infrastructure (0.75%) or provided IT services (0.75%). Regarding the governance framework of the organization/institution to which the surveyed potential users of the research infrastructure EN.I.R.I.S.S.T. belong, the largest percentage (>65.00%) came from institutions of higher education and research (62.50% were part of a university and 6.00% were part of a research institute, respectively). Significantly fewer potential users of the research infrastructure stated that the organization to which they belonged operated as a private company (10.70%), a body of the general government (10.70%), or a body of the public sector (6.70%). Finally, a small percentage of respondents belonged to entities that operated as sole proprietorships (3.40%).

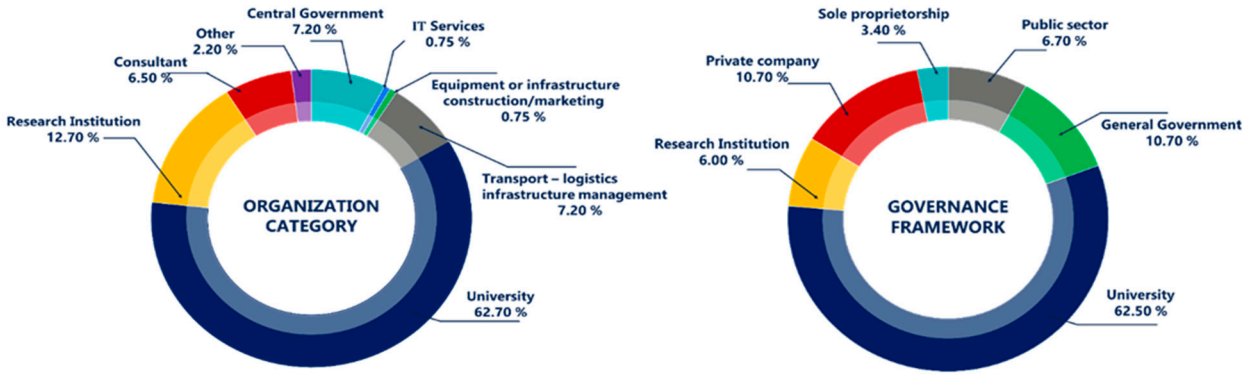

Figure 3. Sample distribution by organization category and governance framework.

Figure 4 shows the respondents' willingness to access data management platforms related to transport, shipping, and/or supply chains. The majority of respondents did not have access to data management platforms related to international transport (97.8%) and inland transport (84.3%), while half of the respondents stated that they had access to data management platforms related to the logistics sector. There was, therefore, a particular interest among potential EN.I.R.I.S.S.T. users in accessing the platforms that this research infrastructure will provide.

The survey results (Figure 3) highlighted the predominant representation of the higher education sector among the respondents, with a relatively lower proportion of participants from transport infrastructure management or logistics entities. Notably, there was substantial interest among potential users in accessing data management platforms related to various segments of the transportation industry, underscoring the critical importance of user-friendly and accessible data interfaces (Figure 4) [12,13].

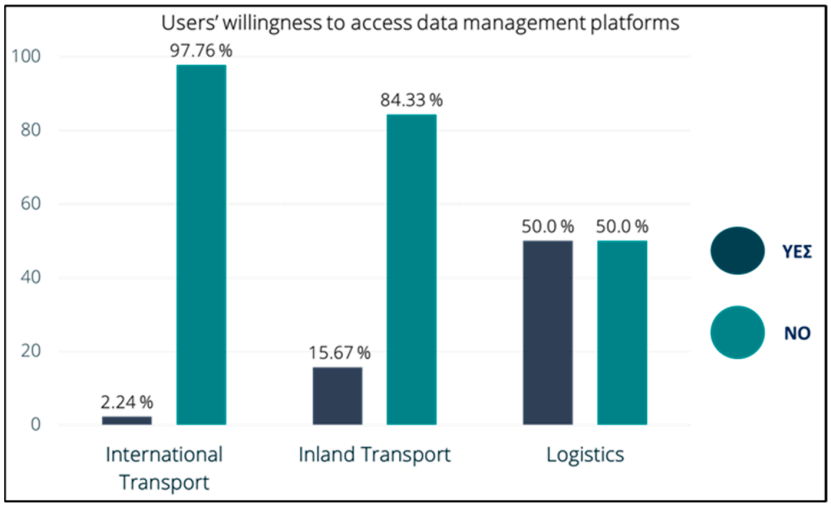

Figure 4. Potential users' willingness to access data management platforms.

Figure 5 illustrates the criticality of developing a data management platform for the transportation sector's business. The corresponding evaluation was conducted on a scale of 1 to 5, with 1 representing an "insignificant" rate and 5 representing a "very significant" rate. The respondents deemed the development of all the proposed platforms to be "extremely critical." The platform related to logistics received the highest percentage of evaluations (53.8%) as "very important," while the inland transport platform received the lowest percentage (32.8%). All platforms were rated as "extremely important" by the respondents for the operation and development of their institutions/organizations. The results of the on-site questionnaires were significantly different from those of the total questionnaires and web questionnaires, with an average evaluation of 4.53 on a scale of 1 to 5, compared to 2.00 for the electronic questionnaire results and 3.71 for the total questionnaire results. As a result, the potential EN.I.R.I.S.S.T. users believed the development of data management platforms in the international transport, inland transport, and logistics sectors would significantly benefit their institutions/organizations.

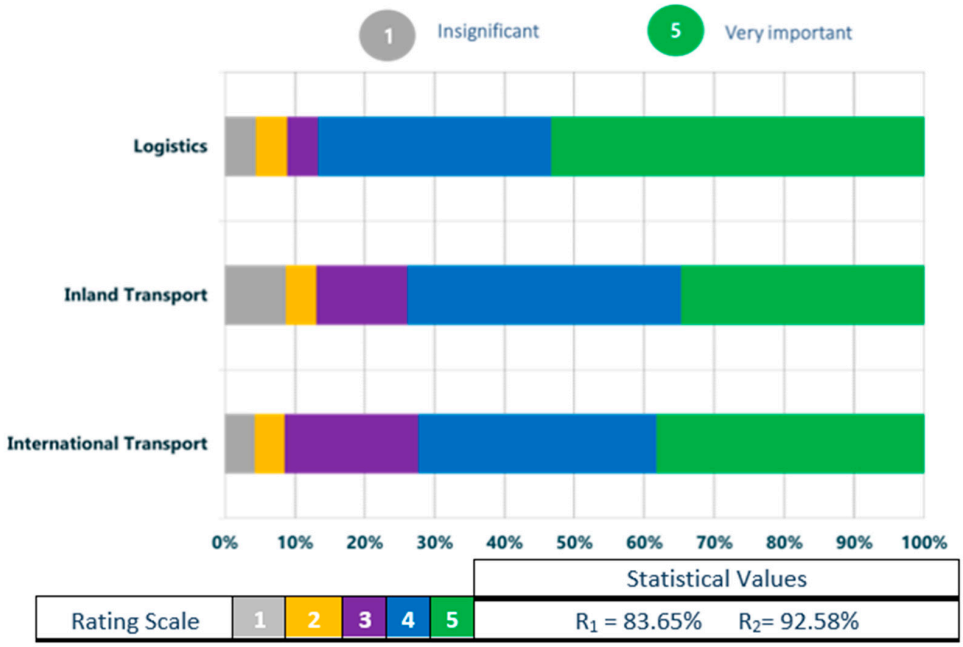

Figure 5. Level of importance for developing data management platforms for the transport sector's business ecosystem.

The evaluation of the importance of developing data management platforms for the transportation sector, as depicted in Figure 5, emphasized a unanimous acknowledgment of the significance of these platforms among the respondents, particularly in enhancing logistics and international transport services. However, varying perspectives were observed, indicating the need for a nuanced approach to accommodate the specific requirements of different sub-sectors within transportation.

The services offered by the project, which were considered to meet the needs of the respondents' organizations/institutions, were divided into services related to inland transport, international transport, and logistics services. In the logistics sector, most respondents chose services related to financial data analysis (80%), decision-making support (70%), and financial product information and freight transport demand forecasting (42.5%). In the inland and international transport sectors, the services with the highest percentage of selection by the respondents were related to data observation, passenger traffic monitoring, intermodal transport information, autonomous vehicles application development, and air transport market monitoring, with a percentage of over 97%.

Consequently, Figure 6 presents the assessment of the needs of the respondents' organizations/institutions to be covered by the proposed services of the project in the sectors of shipping, transport, and supply chains. This evaluation was carried out on a scale of 1 to 5, where 1 signified "insignificant" and 5 meant "very important." The vast majority of respondents assessed the needs of their organizations/institutions that would be covered by the proposed services as "very important." The needs with the highest ratings were related to strategic planning (29.8%), business plan development (33.5%), financial management (31.8%), and financing scenarios' development and price monitoring (27.2%).

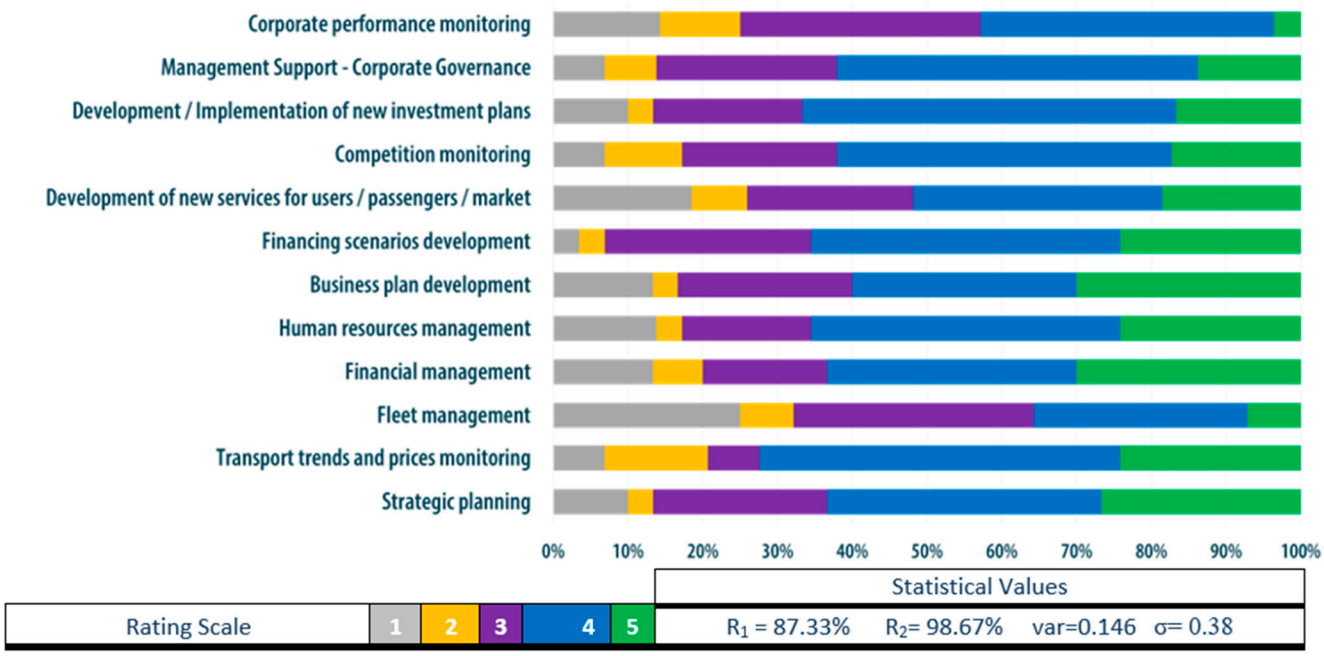

Figure 6. Evaluation of the institutional/organizational needs met with the proposed services (1, insignificant, to 5, very important).

Moreover, the vast majority of the respondents (92.5%) stated that their organizations/institutions had the ability to provide data and/or contribute to the EN.I.R.I.S.S.T. research infrastructure. In the international transport sector, the highest percentage of respondents was available to provide traffic (100%), economic (75%), and financial data (75%). In the inland transport and logistic sectors, the largest shares of the data provision were related to travel demand forecasting (80%), road safety data (70%), passenger traffic

data and indicators' development for intermodal transport evolution (60%), and transport and logistics market activities' monitoring (55%).

In alignment with the identified needs, the evaluation presented in Figure 6 showcased the crucial aspects deemed to be "very important" by the respondents. Strategic planning, business plan development, financial management, and financing scenarios emerged as key areas of focus, reflecting the necessity of comprehensive solutions that support effective decision-making and operational efficiency within the transportation domain.

The responses for each category of prospects and needs by the intelligence services users were analyzed; the key actions that influenced the development of data-driven applications are presented in the following table (Table 2).

Table 2. Key drivers of action towards the development of Intelligence 1 services in the transport sector.

Service Category	Level of Importance *	Key Performance Drivers for Action		
		Operational	**Corporate**	**Business**
Transport trends and price monitoring	High	Demand evolution	Pricing	Business risk
Development—implementation of new investment plans	High	Cost control	Financial conditions	Sustainable development
Financing scenarios' development	High	Opex impact	Capex impact	Cost of capital
Human resources management	High	Cost control	Human capital	Intellectual property
Financial management	High	Cost control	Cash flow	Investors' attractiveness
Strategic planning	High	Environmental impact and contingency	Sustainability and innovation	Business resiliency and sustainability
Business plan development	Moderate	Competition	Added value	Return of equity
Competition monitoring	Moderate	Prices	Market share	Profitability
Development of new services for users/passengers/markets	Moderate	AI and new technology	Service quality	Innovation
Management support—corporate governance	Moderate	Process and scheduling	Asset management	Cash flow
Fleet management	Low	Automated applications	Yield management	Fleet innovation
Corporate performance monitoring	Low	Auditing	Risk management	Share prices

* The level of importance was adjusted according to the outputs of Figure 6, where terms were defined as follows. High: over 60% rated in the range above 4. Moderate: over 40% rated in the range above 4. Low: below 40% rated in the range above 4.

Overall, the survey findings, when analyzed in conjunction with the contextual challenges and technological imperatives outlined in the background section, underscore the significance of developing a holistic, data-driven management system that addresses the diverse needs of stakeholders within the dynamic transportation sector. The results emphasize the critical role of digital infrastructure and sophisticated data management platforms in facilitating informed decision-making and fostering operational excellence within the transportation industry.

5. Conclusions

The current socioeconomic challenges in the transportation domain call for a deeper understanding of the pivotal role of technological advancements in fostering resilience and efficiency within the sector [33]. Research and innovation (R&I) play a crucial role in driving the establishment of new quality standards for the seamless movement of goods and people across national and international borders. This emphasizes the critical need for robust research infrastructures (RIs) to facilitate data-driven decision-making processes and to enhance the overall resilience of the transportation business ecosystem [34].

This analysis highlights two fundamental principles that must guide the development of an effective RI in the transport sector: the technical accuracy of metadata and the effective presentation of results tailored to the needs of stakeholders and decision-makers. These principles serve as the cornerstone for enabling robust modeling outputs that are instrumental in fortifying the resilience of the transport industry [35,36].

This paper aims to identify and designate the key drivers necessary for implementing actionable strategies within this framework. By emphasizing the integration of intelligent services, the paper likely aims to propose a systematic approach to enhancing the efficiency, productivity, and competitiveness of transport enterprises through the use of advanced technological solutions and strategic planning.

The results of the questionnaire, which was distributed to transportation and logistics industry professionals, unequivocally highlighted the genuine demand for comprehensive data analytics, event observation, cost–benefit analysis, and market trend forecasting within the supply chain ecosystem. Moreover, the evaluation of the importance of developing data management platforms for the transportation sector emphasized the unanimous acknowledgment of the significance of these platforms among the respondents, particularly in enhancing logistics and international transport services. However, varying perspectives were observed, indicating the need for a nuanced approach to accommodate the specific requirements of different sub-sectors within transportation.

In alignment with the identified needs, the evaluation presented in Figure 6 showcased the crucial aspects deemed "very important" by the respondents. Strategic planning, business plan development, financial management, and financing scenarios emerged as key areas of focus, reflecting the necessity of comprehensive solutions that support effective decision-making and operational efficiency within the transportation domain.

These survey findings, when analyzed in conjunction with the contextual challenges and technological imperatives outlined in the background section, underscore the significance of developing a holistic, data-driven management system that addresses the diverse needs of stakeholders within the dynamic transportation sector. The results emphasize the critical role of digital infrastructure and sophisticated data management platforms in facilitating informed decision-making and fostering operational excellence within the transportation industry.

The novelty of this paper lies in its emphasis on the development of a comprehensive conceptual framework for intelligent services and platforms specifically tailored to transport enterprises. It also highlights the importance of a robust data flow analysis framework that addresses conflicting user requirements, resource limitations, and the need for maintaining flexibility in service implementation. Additionally, the paper emphasizes the role of the services proposed by the EN.I.R.I.S.S.T. research infrastructure in providing accessible data, user-friendly interfaces, and data analysis tools for enhancing strategic development and competitiveness in the transport domain.

In terms of further research in the field, it would enhance the research's novelty to delve more deeply into the specific requirements of intelligence services customized to the identified distinct categories within the transportation sector. This entails refining the survey methodology and implementing a more targeted approach to data collection, encompassing a comprehensive range of stakeholders and industry representatives. Furthermore, the incorporation of specific case studies and practical scenarios within the transportation sector will facilitate a more nuanced understanding of the challenges and requirements

faced by different entities. By employing a more detailed and refined survey framework, the aim is to capture specific insights that will contribute to the development of a robust and inclusive data-driven management system for the transportation sector.

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