sustainability

Article

The Impact of Information Distortions on Decision-Making: A Case Study in Land–Sea Transport Chain Planning

Adam Torok [1,2], Iouri Semenov [3], Ludmiła Filina-Dawidowicz [4,*] and Wojciech Durczak [4,5]

[1] Faculty of Transportation Engineering and Vehicle Engineering, Budapest University of Technology and Economics, Műegyetem rkp. 3, 1111 Budapest, Hungary; torok.adam@kti.hu
[2] Department for Logistics, KTI—National Institute for Transport Sciences, Than Karoly Str. 3-5, 1119 Budapest, Hungary
[3] Faculty of Economics in Szczecin, WSB Merito University in Poznan, 5 Powstancow Wielkopolskich Str., 61895 Poznan, Poland; iouri.semenov@wsb.szczecin.pl
[4] Faculty of Maritime Technology and Transport, West Pomeranian University of Technology in Szczecin, Ave. Piastów 41, 71065 Szczecin, Poland; wojciech.durczak@zut.edu.pl
[5] Maritime Office in Szczecin, 4 Stefana Batorego Sqr., 70207 Szczecin, Poland
* Correspondence: ludmila.filina@zut.edu.pl

Abstract: Management based on reliable, complete, and up-to-date information is key to increasing a transport chain's effectiveness and sustainability. The instability of the business environment and the increase in competition have contributed to the growth of challenges faced by managers of transport and logistics companies who make decisions using low-value information exposed to significant distortions. This article aims to investigate the impact of information distortions on decision-making quality and to determine the probability of making trustworthy decisions in freight land–sea transport chain planning. The research was carried out in several stages, which included the formulation of rules for detecting information distortions, as well as distortion clustering and evaluation of their impact on decision quality. A methodology to assess the probability of making trustworthy decisions was developed. It was shown that information value directly impacts the quality of decisions related to transport chain planning for both traditional and unique/occasional freight. In the case of significant information distortion, the manager's ability to assess available information considerably increases, especially in crises, when the lack of time to verify information threatens the accuracy of decisions. This study's results may be useful for transport and logistics companies' managers, who make decisions using information obtained from various sources.

Keywords: land–sea transport chain; sustainable transport; decision trustworthiness; information distortion; freight transportation planning; decision-making quality

check for updates

Citation: Torok, A.; Semenov, I.; Filina-Dawidowicz, L.; Durczak, W. The Impact of Information Distortions on Decision-Making: A Case Study in Land–Sea Transport Chain Planning. *Sustainability* **2024**, *16*, 5568. https://doi.org/10.3390/su16135568

Academic Editor: GuoJun Ji

Received: 8 May 2024
Revised: 18 June 2024
Accepted: 25 June 2024
Published: 28 June 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Knowledge is becoming one of the most appreciated resources, the total value of which soon may exceed the valuation of other produced goods. The instability of the business environment contributes to various threats that negatively affect the knowledge possessed by managers and consequently cause material, financial, image, and other losses [1]. Therefore, access to reliable, up-to-date, and complete information is a condition for ensuring companies' operational effectiveness, including those operating in the transport and logistics (T&L) industry. It should be emphasised that human decisions impact a company's management, but the quality of information possessed by managers affects decision accuracy. A literature review [2] revealed that 80% of companies believe that using low-value information threatens their market position, and 54% stated that the severity of this factor will increase over the next 20 years. It was found that in the Asia-Pacific region, 82% of companies had problems with obtaining valuable information. In North America, such problems were faced by 78% of surveyed companies, and in Europe, they were faced by

74%. Therefore, more than 35% of the companies examined are increasing their efforts to enhance the value of the information they possess [2].

The necessity of developing verification procedures and techniques for determining and eliminating information distortions was highlighted [3,4]. The intricacy is related to the variety of causes of distortions, which may be random or intentional, and differ in the place of origin or in the dynamics of changes along the information processing trajectory. Therefore, the management of regional and international sustainable land–sea transport chains (LSTCs) becomes particularly vulnerable to such distortions [5,6].

Since the beginning of the 21st century, sustainable LSTC management has become a key issue for leading T&L service providers. On the one hand, this is due to changes observed in these service markets resulting, e.g., from the increasingly frequent shift in freight flow from intercontinental to regional T&L chains. On the other hand, the modernisation of transport infrastructure elements within these chains impacts the decisions regarding individual task performance. As an example, the modernisation of the Świnoujście–Szczecin fairway (Poland) to a depth of 12.5 m can be mentioned [7]. Due to the increased parameters of the fairway, vessels with greater dimensions than before may enter the fairway, which impacts the ship traffic management and port services planning. This infrastructure modernisation increased the attractiveness of the Baltic–Adriatic transport corridor running through the ports of Świnoujście and Szczecin along the Oder Waterway [8]. The expansion of the hinterland infrastructure of this corridor was continued in 2022–2023, allowing both shorter delivery times for conventional cargo transported from Scandinavia to the southern areas of the European Union (EU) and easy access to the northern EU regions. Moreover, the transshipment growth in Świnoujście and Szczecin ports within seven main commodity groups in 2023 (35,322.7 thousand tons) compared to 2020 (31,177.5 thousand tons) was also observed [9]. The changes introduced have also resulted in an increase in non-conventional freight deliveries, such as super-heavy or oversized cargo. This raises the problem of adapting the decision-making process related to LSTC management to changes influenced by the business environment, considering possible information distortion occurrences.

According to the conducted literature review, different problems related to information distortions take place during transport chain planning and execution. However, the issues of assessing the probability of making trustworthy decisions, considering information distortion occurrence, during LSTC planning for both traditional and unique/occasional freight were studied selectively. The mentioned problems must be explored complexly to ensure effective planning and management of sustainable LSTCs.

To conduct the study, three research questions were formulated:

1. What categories and groups of information distortions impacting decision-making quality during freight LSTC planning may be distinguished?
2. What is the impact of information distortions on LSTC planning quality?
3. What is the probability of making trustworthy decisions taking into account information distortions' impact on decision-making quality during freight LSTC planning for both traditional and unique/occasional freight?

The article aims to investigate the impact of information distortions on decision-making quality during freight LSTC planning and to determine the probability of making trustworthy decisions during these chains' planning. In this regard, a methodology to assess the probability of making trustworthy decisions was developed.

The article includes a literature review section (Section 2) that shows the results of available research studies conducted within the analysed subject area. The Materials and Methods section (Section 3) describes the methodology developed to carry out the research. The elaborated outcomes of the research are presented in the Results section (Section 4), where the assessment of information distortions' impact on the decision-making quality is presented. To sum up, the conclusions are drawn and discussions are presented in the Discussions and Conclusions section (Section 5).

2. Literature Review

The smooth operation of LSTCs supports freight exchange worldwide, enabling these chain participants to obtain certain benefits [6,10]. The planning and managing of sustainable transport chains are complex decision-making processes [11,12]. Therefore, LSTC managers may face problems while coordinating the activities performed during freight delivery [5,13]. Different cargo may be transported within an LSTC, including traditional freight (standard procedures are applied to perform the transport task) and unique/occasional goods (the procedures are adjusted/created every time the company receives a transport order due to specific cargo features or there is a need to ensure unique transport conditions). LSTCs are created using road, rail, maritime, inland navigation, and air transport modes. Transport chain planning deals with the need to consider different aspects, such as time of freight delivery [14], transport process costs [15], reliability, maintainability, safety [16], environmental effects of transport activity [17], and others.

When planning and managing an LSTC, it is essential to possess reliable, complete, and credible information [18], which may concern the demand for services [19], the financial resources incurred [20], cargo type [21], and the transport links involved in transport chain planning taking into account sustainable development principles [22,23]. During transport chain planning and implementation, the information is processed at various management levels [24], and the effectiveness of its use depends on the experience of managers involved in management activity [25]. Basing the decision-making process on low-quality information generally negatively impacts a decision's trustworthiness [26]. Disruption in the communication networks used in the LSTC and the whole supply chain is perceived as one of the causes of information distortion [27], which creates the problem of ensuring the supply chain's resilience capabilities to various disruptions [28].

Different problems related to information distortions have been described in the available literature. The problems of information distortion in transport chains and, above all, entire supply chains were extensively analysed by Wang et al. [29]. A qualitative assessment of the information gap's impact on decision-making and identification of their causes and effects was carried out by Wachnik et al. [30]. The role of transport processes inspection and supervision necessary to obtain reliable information was emphasized by Zieja et al. [31]. The problem of information dispersion due to the use of a networked scattered management mode has been mentioned by Liao et al. [32]. Moreover, the issues of making complete information available to all partners involved in the supply chain have been studied [33]. However, it should be noted that these problems were analysed considering the individual conditions of related decision-making processes.

In the literature studies, the need to ensure smooth information sharing that may allow deriving advantages or profits for supply chain participants is highlighted [34,35]. The factors that impact information sharing include interaction routines, personal connection, organizational compatibility, incentives, project payoffs, top management commitment, supply network configuration, and others [36,37]. It has been noted that the quality of information sharing positively impacts supply chain sustainability [38]. Xue et al. [39] and Tang et al. [40] investigated different information-sharing strategies; they stated that information transparency helps to improve the supply chain's overall performance. In turn, Lee et al. [41] proposed a methodology for information quality assessment. However, these studies do not take into account specific groups of information distortions that may occur and impact LSTC management.

Different IT solutions are introduced to facilitate information flow and sharing [42,43], allowing the integration of supply chain participants and their internal and external value chains [44]. The evolutionary stability strategy was determined by Zhiwen et al. [45], who also built an evolutionary game model of supply chain logistics information collaboration based on a two-echelon supply chain consisting of two supplier levels. The first level of suppliers provides raw materials or components, but the second level is involved in final product delivery. It was stated that the supply chain manager could set specific measures to enhance the collaborative environment for supply chain logistics information, as well as motivate the enterprises within the supply chain to implement collaborative behaviours regarding this information.

Thapa et al. [46] noted that it is impossible to stop the spread of misleading information and searched for ways to analyse and predict it. Qiao and Zhao [47] confirmed that alleviating information asymmetry can help to achieve information transparency and control numerous risks by reducing uncertainties in supply chains. Vosooghidizaji et al. [48] classified the selected literature positions, paying attention to supply chain features, types of information asymmetry, and other aspects. However, in these studies, the rules for distorted information clustering were not formulated.

Proper information structuring and correcting can help to make key decisions [27,49]. Li et al. [50] highlighted the impact of information accuracy on decision-making in freight transport planning, considering possible adverse events. Some approaches to solving the mentioned problems, including event analysis and minimizing distortions based on the use of structured data and its correction and completion, were proposed by Benavente et al. [51]. In contrast, in a later publication [52], the desirability of applying a combination of information characteristics, such as incompleteness and inherent uncertainty, in simulation models has been demonstrated. At the same time, uncertainty was considered as the lack of knowledge or information about any event's future or outcome. A way to assess the probability of making a correct decision was also proposed [53]. It should be mentioned that in the analysed research papers, the impact of information distortions on decision-making trustworthiness in LSTC planning was not explored in detail.

Available research studies also analyse risks associated with transport chain operation [54,55]. Ersoy and Tanyeri [56] noted that delivery risks are associated with cargo loss/damage, delivery to a wrong address, or unforeseen route obstacles. Different methods to manage disruptions and risks are applied [57–59]. These methods may be used to improve managing plans, information flow in transport chains, or business impacts [60,61]. Nevertheless, categories of information distortion significance considering the risk level of making wrong decisions were not investigated.

Particular attention should be paid to the research results presented by Griffin et al. [62], who introduced the concepts of information expected value and expected value of partially perfect information. However, in these studies, there is a lack of a comprehensive view of the information value as a key element of decision-making effectiveness, clustering information according to value, and assessing the information distortions' impact on managerial decision quality.

Based on the literature review, it can be concluded that low-value information still occurs in T&L industry companies, which justifies the need to research the possible impact of various information distortions on LSTC planning and subsequent management. Therefore, there is a need to develop a methodology for assessing the probability of making trustworthy decisions, considering the occurrence of information distortions, during LSTC planning for both traditional and unique/occasional freight.

3. Materials and Methods

3.1. General Assumptions and Research Methodology

The general approach used to conduct the research is shown in Figure 1.

The results of the literature studies analysis showed that problems arising during decision-making, including the information distortion assessment, have been widely discussed [29,49]. However, in these studies, distortions were evaluated without categorising them according to their significance, and these studies were based on the hypothesis that there is an undetermined probability of such information distortion leading to a reduction in decision-making effectiveness.

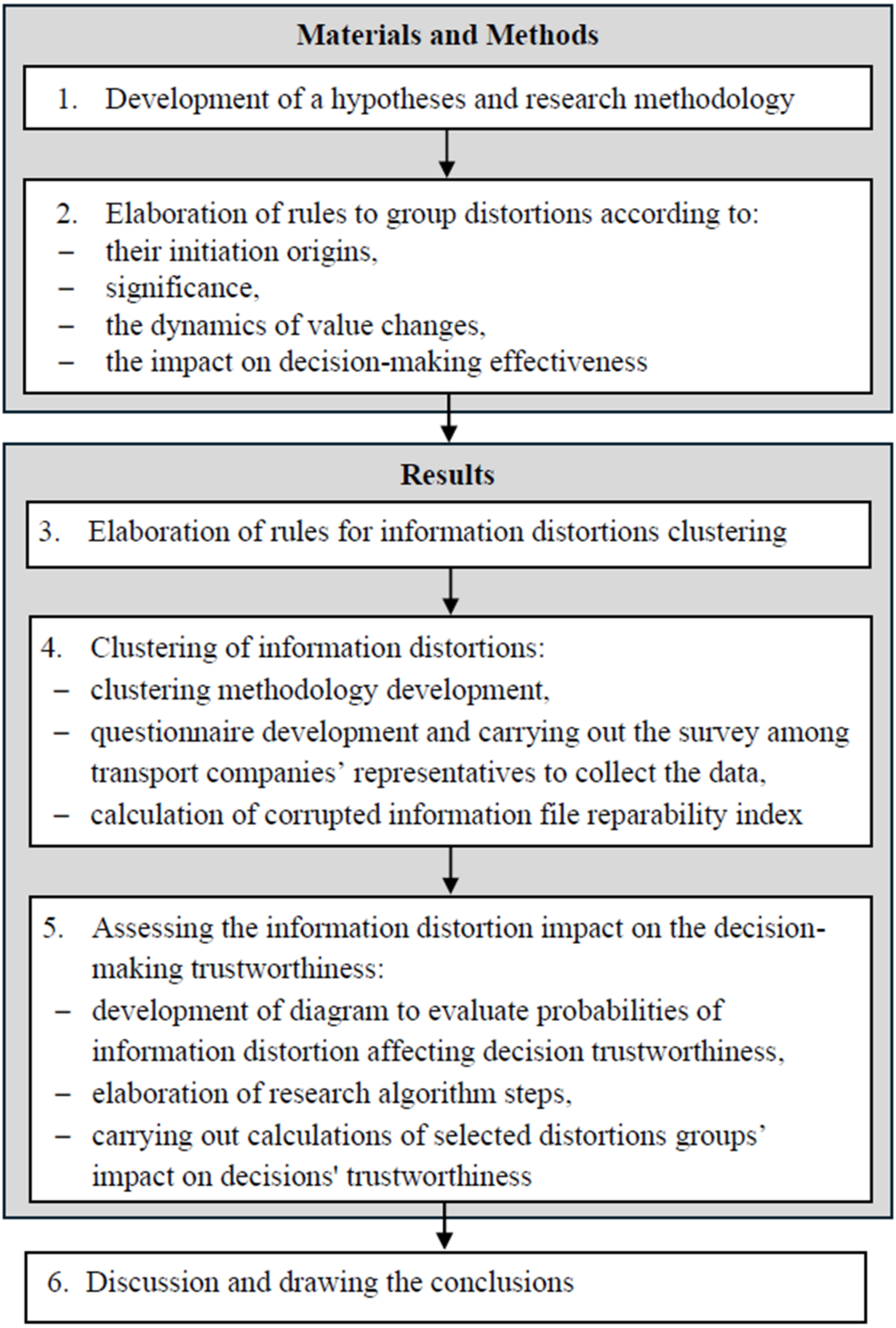

Figure 1. Research methodology (own elaboration).

The authors of the present article defined the following hypotheses:

Hypothesis 1: *During the decision-making process, it is possible to collect information from distributed communication network sources that can allow to obtain the following*:

- High-value information, the usage of which will form the basis for effective decision-making;
- Valuable information (exposed to insignificant distortions), the application of which will not significantly reduce the decision-making quality;
- Low-value information (exposed to significant distortions); the decision quality based on its use will depend on the manager's experience and qualifications.

Hypothesis 2: *For sustainable LSTC planning, managers must consider the quality of the obtained information as one of the primary factors influencing the accuracy of decisions*.

Hypothesis 3: *In practice, the information value depends on its reliability and is exposed to the risk of distortions*.

Within this research study, it was proposed to group detected distortions according to the following criteria:

- Initiation origins (e.g., external, internal, mixed) (Section 3.2);
- Significance—assessed by the risk level of making wrong decisions (Section 3.3);
- The dynamics of value changes (e.g., constant/variable; negative/positive) (Section 3.4);
- The impact on decision-making effectiveness (Section 3.5).

It was assumed that three types of decision groups would be analysed:

GDx_1—set of decisions related to the elaboration of a schedule for sustainable transportation services (e.g., the transportation frequency for the given route);
GDx_2—set of decisions related to the selection of transport routes considering road constraints;
GDx_3—set of decisions related to the organization of transport processes as environmentally friendly, economically viable, and socially equitable.

During LSTC planning, T&L industry companies' managers commonly make the decisions associated with these groups. In order to analyse these decisions, the appropriate information files were created.

This research is focused on information distortions that may occur during LSTC planning for two groups of transported cargo:

- Traditional freight—that is transported by the company according to known and previously set procedures (e.g., bulk or general cargo, containers);
- Unique/occasional freight—that is transported from time to time; special conditions should be ensured by the transport company, or special procedures should be developed/adjusted to perform the transport order (this cargo will be individual for a particular company, e.g., sensitive loads [21]).

In order to prove the above hypotheses, an appropriate methodology was developed that included three stages:

- Elaboration of rules for information distortion clustering (Section 4.1);
- Clustering of information distortions (Section 4.2);
- Assessing the information distortion impact on the decision-making trustworthiness (Section 4.3).

This study provides the investigation of information distortion clusters. The approach to creating these clusters for the appropriate information files is shown. Three rules for distortion clustering are proposed (Section 4.1).

The methodology to conduct the clustering process is proposed in Section 4.2. Information distortion clusters and their characteristics (subgroups) were identified.

The questionnaire survey was developed to collect the data needed to conduct calculations using the developed methodology. The required data were collected in 2021 and 2022. The survey was carried out among 12 companies' representatives who agreed to fill in the questionnaire. A total of 11 respondents represented T&L sector companies located in Poland (92% of collected opinions), and only one response was given by foreign company representatives (8% of collected opinions). Respondents were managers employed in small and medium-sized companies with fleets operating on the freight market for 10–15 years. Practitioners had more than 10 years of working experience in LSTC planning and represented road transport and freight forwarding companies. The respondents were involved in transport task planning within the Baltic–Adriatic transport corridor that runs through the ports in Świnoujście and Szczecin.

The practitioners representing the 12 investigated companies answered the following research questions:

1. Were the received information files subjected to distortion (possible response options: never, sometimes, always)?
2. Had the noticed information distortions affected the quality of the decisions made (possible response options: never, to a small extent, significantly)?

The study was carried out considering the assumption that the index of corrupted information file reparability (IDR) based on non-quantifiable risk (NQR) may be used in practice to assess the decision-making process stability. The range of NQR may be assessed as probability within the interval $[0, 1]$.

In Section 4.3, the methodology to evaluate the impact of information distortion on the decisions' trustworthiness is developed. The digital maturity assessment (DMA) modelling technique [63] was applied. Additionally, Martins' [64] model and Bayesian rules [65] were used to calculate the probability of information distortion's impact on decisions. The term "decision trustworthiness" was implemented.

During this research stage, the diagram for investigating the probability of information distortion affecting decision trustworthiness was developed, and the steps of the research algorithm were proposed. Based on data collected from selected companies' representatives using the questionnaire survey, calculations using an Microsoft 365 Excel sheet were carried out for decisions taken for traditional and unique/occasional cargo transported within the LSTC. The three aforementioned groups of decisions were investigated. Then, the obtained simulation results were analysed, and conclusions were drawn.

3.2. Information Distortions According to Their Origins

To address the problem of ensuring LSTC resilience to various threats, appropriate techniques should be developed and implemented. Threat origins may include erroneous verification of collected information, the inexperience of personnel working with databases, imperfect procedures for organising message exchange, or faulty software use. In this perspective, information distortions of a random or intentional nature may result in harmful irregularities. Since the origins initiating information distortion may be local or dispersed and characterised by different complexity and harmfulness levels, it is necessary to identify and systematise them (Figure 2).

Software packages may be designed and applied to protect the user from threats, e.g., web application firewalls (WAFs), multi-factor authentication (MFA), validating user input (VUI), and others. Each software mentioned above contains weaknesses, including the inability to work with systems related to freight transport planning that use unclassified and confidential information sent over distributed communication networks. Therefore, it is advisable to continuously improve company procedures and collect good practices to enhance the detection and removal of low-value information causes. Knowledge on the origin of information distortion may be helpful to create plans and implement actions needed to identify and reduce its negative impact.

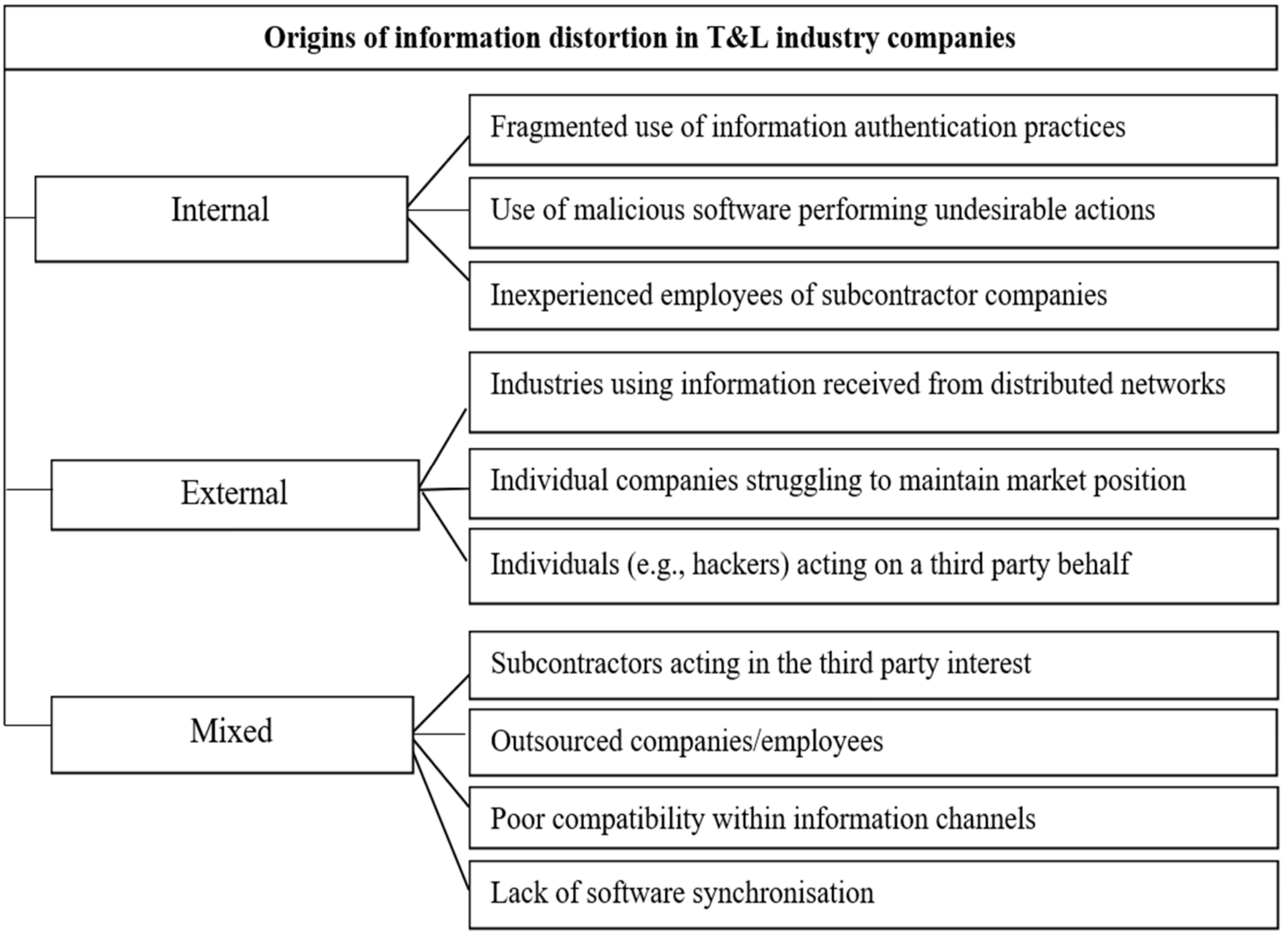

Figure 2. Origins of information distortion (authors' elaboration).

3.3. Information Distortions According to Their Significance

Two basic ways to provide information to managers may be distinguished: verbal (e.g., messaging) and non-verbal (e.g., images/video). Let us assume that verbal information consists of individual bits, and that even a small distortion may lead to a loss of reliability in the knowledge contained in the information file. This creates a multidimensional premise for investigating and clustering information distortions, the significance of which depends on their transparency—overt or covert (detectable and undetectable)—and susceptibility to correction (correctable or uncorrectable). Therefore, two categories of information distortion significance have been identified (Table 1).

Table 1. Categories of information distortion significance (authors' elaboration).

Distortion Categories	Distortion Characteristics
Type ***A***: significant distortion (worthless/low-value information)	The risk level of an incorrect decision is high and depends on both the severity of corrupted files and decision-making conditions (e.g., emergency, lack of time)
Type ***B***: trivial distortion (high-value information)	The risk level of an incorrect decision is low and depends on the manager's experience and skills, as well as IT effectiveness (e.g., software: Language Tool, Hunspell).

The clustering process was applied to allocate the information distortion to a particular category. The following assumptions were proposed:

1. Distortions are considered significant if, uncorrected, they contribute to the loss of timeliness, reliability, and completeness of the collected information and cause decision-making to be highly risky.
2. Distortions are considered insignificant if they do not contribute to the loss of collected information value and their use does not increase the decision-making risk.
3. Information should be corrected if the information recovery time is shorter than a certain threshold value. In other cases, distortions are assigned to poorly detectable or uncorrectable categories.

3.4. Information Distortions According to the Dynamics of Value Changes

The value of information (VOI) is the amount that a decision-maker would be willing to pay to have it. The manager's assessment of information value accuracy, considering the possible distortion significance, is a condition for decision-making effectiveness. Based on such an assessment, the manager may choose between two options: proceed with decision-making based on the collected information or correct it.

Let us introduce the idea of the targeted information value, which includes the set $\langle X(t_0, t_1)\rangle$ of uncorrected data files $<x_i>$ collected during the period $[t_0, t_1]$ (Equation (1)):

$$X(t_0, t_1) = f_1\{x_1, x_2, \ldots, x_i\} \tag{1}$$

In most cases, this set of files may contain distorted information files. Therefore, we are dealing with a set $<X^*>$, which requires information verification and consequently its correction during the next period $[t_1, t_n]$. The corrections made to the set $<X^*>$ can result in an increase (X^+) or decrease (X^-) in information value (Equations (2) and (3)):

$$X^+(t_1, t_n) = f_2\{x_1^*, x_2^*, \ldots, x_n^*\}, \tag{2}$$

$$X^-(t_1, t_n) = f_3\{x_1^{**}, x_2^{**}, \ldots, x_n^{**}\}. \tag{3}$$

Using Hamming's theory (linear error-correcting code), an algorithm for verification and correction of information distortion was developed [66], raising the information value to (X^+) level. The fundamentals of the algorithm are outlined as follows:

1. Let us set that the effectiveness criterion in correcting the corrupted information files is $VOI \to max$.
2. The integral measure $D(X, X^*)$ of distortion detection effectiveness can be determined using Equation (4) [67]:

$$D(X, X^*) = \left\{ \begin{array}{l} 1.0,\ \text{if}\ X \to X^*,\ significant\ distortions\ that\ should\ be\ detected, \\ 0.0,\ \text{if}\ X \to X^*,\ insignificant\ distortions, no\ need\ for\ detection \end{array} \right\}. \tag{4}$$

3. The local measure $d(x, x^*)$ of distortion correction effectiveness for corrupted information files from the set $\langle X^*\rangle$ can be specified using Equations (5) and (6):

$$d(x_i, x_i^*) \geq 0\ \text{for}\ \forall\ X \ni\ \{x_1,\ x_2, \ldots, x_i\} \cap \forall\ X^* \ni\ \{x_1^*,\ x_2^*, \ldots, x_i^*\}, \tag{5}$$

$$d(x_i,\ x_i^*) = \left\{ \begin{array}{l} 1.0, \text{if}\ x_i^* \to x_i^+,\ condition\ of\ effective\ correction, \\ 0.0, \text{if}\ x_i^* \to x_i^-,\ condition\ of\ ineffective\ correction \end{array} \right\}. \tag{6}$$

The proposed approach allows the allocation of distorted information considering the dynamics of information value changes.

3.5. Information Distortions According to the Impact on Managerial Decision Effectiveness

Based on the analysed literature studies, experience, and own research results, it can be stated that low-value information can result in inappropriate managerial decisions with short- and long-term consequences. Let us formalise this statement.

Let a manager make decisions within several T&L activity areas Ω_i, including supply planning, warehousing, handling, and transportation. These areas form a space R^n of decisions made during order processing. Within the boundaries of each T&L activity area Ω_i the trajectories of decision-making processes concerning each *i-th* activity are established. Since their realisation takes place over the period $T = [t_0, t_k]$ (where t_k—the moment of planning process completion) the course of such trajectories $[\dot{x}_i]$ can be determined using Equation (7):

$$[\dot{x}_i] = f(x_i, t_i),\ x_i \in \Omega_i,\ \sum \Omega_i \subset R^n;\ f : T[0.t_k],\ f(t_0) = 0;\ i = 1, n. \quad (7)$$

From Equation (7) it follows that each i-trajectory of the decision-making process $(x_i,\ t_i)$ corresponds to the course of only one T&L activity and contains only one trivial solution $\langle x_i\ (0)\rangle$, fulfilling the initiation conditions $(x_i(0) \equiv 0;\ t_0 \equiv 0)$, i.e., "receiving the order" results in the only correct decision "planning process beginning". All other decisions are not trivial. This raises the problem of ensuring their stability along the decision-making trajectory for each i-th T&L activity.

Let $\langle \varepsilon \rangle$ be a threshold value depending on the information distortion level. Then, the initiating decision $\langle x_0 \rangle$ is stable according to the Lyapunov criterion [68] ("receiving the order—the LSTC planning process beginning"). However, for the other decisions set $\langle x_i \rangle$, it can be argued that they will not require corrections (they will be stable) if, for any LSTC management process start time $\langle t_0 \rangle$ and a threshold value $\langle \varepsilon_i \rangle$, there is a variable $\langle \Delta \rangle$ whose value depends only on the transport process's beginning conditions. Whereby, for each subsequent decision $\langle x_{i+1}(t) \rangle$, the following condition is met (Equation (8)):

$$\|(x_{i+1}(t))\| < \varepsilon_i. \quad (8)$$

In the practice of T&L companies' operation, it is known that decision-making processes are unstable both due to the changes in the business environment and information distortions, which can be expressed as follows (Equation (9)):

$$(\forall \varepsilon_i > 0), (\forall t \in T),\ (\exists \Delta(t_0) > 0),\ (\forall x_i \in X)\ (\forall t \geq t_0; t \in T) \rightarrow \|x_i(t)\| = \Delta(t_0) > \varepsilon_i\,. \quad (9)$$

Equation (9) shows that even corrected information can initially contribute to changes in the decision-making trajectory, which in the short-term perspective can lead to significant deviation. Therefore, significant differences can be observed between the effects expected during LSTC planning and the results achieved after a decision's implementation.

4. Results

4.1. Elaboration of Rules for Information Distortion Clustering

Managerial decision quality depends on information accuracy [69]. Using the recommendations formulated by Griffin et al. [62], it can be argued that in the case of significant distortions, the manager generally strives to eliminate them by taking $\langle j \rangle$ corrective activities, the effectiveness of which can be evaluated through the net benefit (NB) indicator, which in turn can be calculated for each j-th correction as follows (Equation (10)):

$$NBj = \frac{TP \cdot SPJD\ -\ FP \cdot SPJD}{TP + FP} \cdot \frac{P}{P-1}, \quad (10)$$

where

TP—the number of information files with significant distortions detected and removed;
FP—the number of information files with undetected and unremoved distortions;

$SPJD$—the degree of decision quality increase after carrying out the j-repair of corrupted information files; $j = 1, \ldots, J$;
P—the probability of increasing the information value and decisions' quality.

Collected information value depends on the j-corrective activities' effectiveness, reducing the number of information files, and can be evaluated by increasing the value of all repaired files through the expected value of information (EVI) index [62] (Equation (11)):

$$EVI(j) = F\left[NB_1(x_1^*) \cup NB_2(x_2^*) \cup NB_3(x_3^*) \ldots \cup NB_j\left(x_j^*\right)\right]. \quad (11)$$

Whereby the activities $\langle j \rangle$ increase the NB value to NB_{max} level that may be expressed as follows (Equation (12)):

$$NB(x_1^*, x_2^*, x_3^*, \ldots, j) \rightarrow NB_{max}(x_1, x_2, x_3, \ldots, j). \quad (12)$$

The growth in the information value (after corrective activities were taken) was analysed considering the increase in the expected value of the perfect information ($EVPI$) index [62] and finally evaluated as a measure of the new knowledge discovery (KD) (Equation (13)):

$$KD = f[\Delta EVPI(j)] = NB_{max}(x_1, x_2, x_3) - NB(x_1^*, x_2^*, x_3^*), \quad (13)$$

where

x_1—information file used during the development of the transportation work schedule;
x_2—information file used during decision-making on transport route selection;
x_3—information file used during the organization of the transport process.

Based on the above, the following rules were formulated:

Rule 1: The more contractors involved in the services provided within the LSTC, the higher the probability of a decrease in the information value in the messages received (Figure 3).

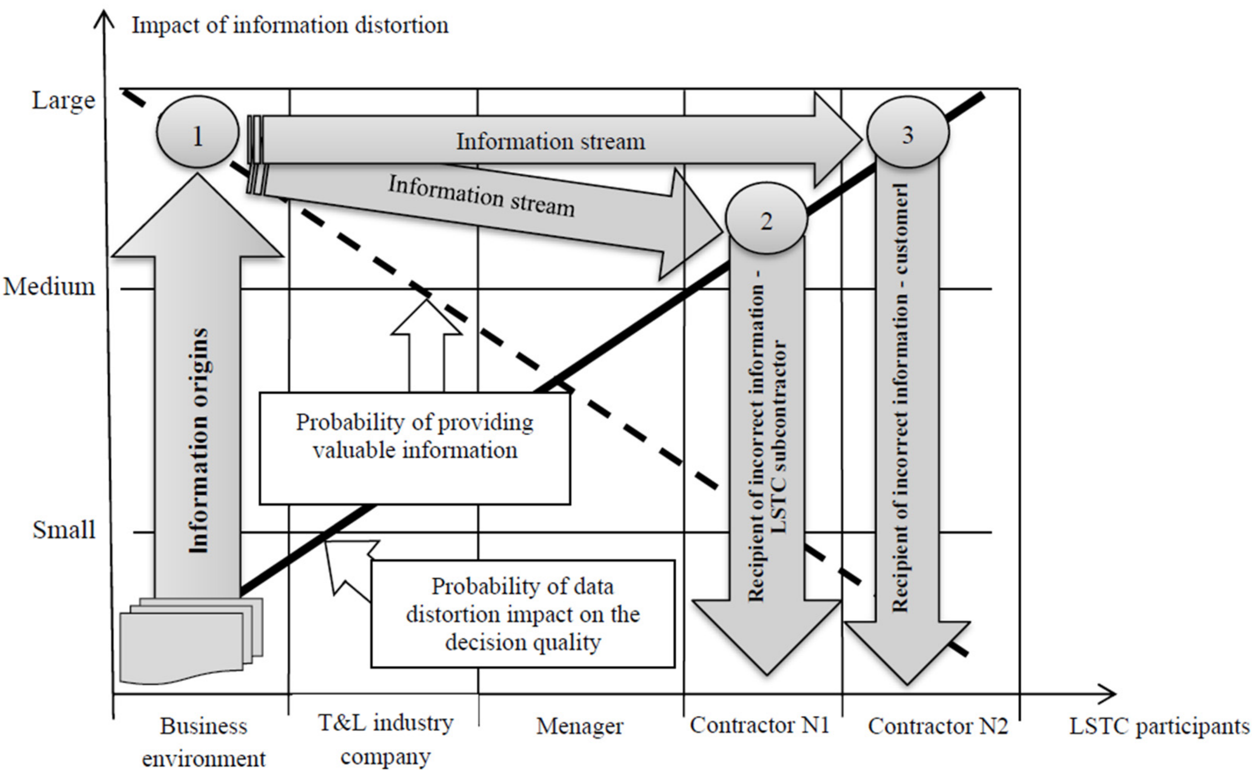

Figure 3. Changes in information value in messages within an LSTC (authors' elaboration), where 1—information provision point; 2,3—points of information receipt by contractors.

Rule 2: According to the assigned tasks, the value of information provided within the LSTC is adequate to the reliability of messages generated across its weakest link.

Rule 3: In the case of multiple weakest links, the continuous review and correction of the generated files will be a prerequisite for effective LSTC planning and management to prevent the synergistic effect due to combining information distortions.

4.2. Clustering of Information Distortions

Information distortion clustering was performed using the following steps:

1. Let us assume that the database contains uncorrected information $X^* = \left\{x_1^*, x_2^*, \ldots, x_n^*\right\}$.
2. Let us select two categories (groups of significant and trivial distortions) and allocate the detected distortions to them, using the metric of their similarity $d(x, x^*)$ (Equations (5) and (6)).
3. The compared distortions' convergence could be assessed by applying Pearson's linear correlation index or Spearman's rank correlation index (rs) [70] (Equation (14)):

$$rs = 1 - \frac{6\sum_{i=1}^{n} d(x, x*)_i^2}{n(n^2 - 1)}, \quad (14)$$

where

n—the number of observations during the evaluation of compared distortions' similarity;
$d(x, x^*)_i$—the measure of compared information distortions' convergence (x, x^*).

4. By changing the distance thresholds $d(x, x^*)$, where $0 \leq d_0 \ldots < d_m \leq 1$, both distortion clusters and their groups/subgroups may be formed, and their hierarchy depth could be assessed.

The information distortion grouping scheme is presented in Figure 4.

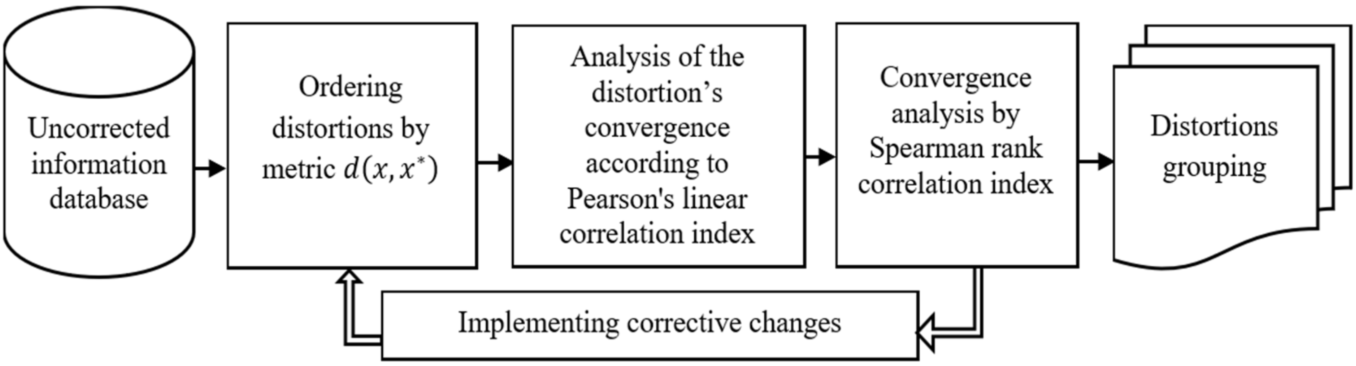

Figure 4. Information distortion grouping scheme (authors' elaboration).

Applying the scheme presented in Figure 4, it was possible to achieve the clustering results of significant information distortions provided within the messages exchanged during LSTC planning (Table 2). Based on the literature review [27,28,71] and own observations, the information distortion clusters and their characteristics (subgroups) were identified. Utilizing data collected from representatives of selected surveyed T&L industry companies it was possible to determine the index of corrupted information file reparability (IDR) for both traditional and unique/occasional freight.

Table 2. Results of significant information distortion clustering for messages exchanged within LSTC (authors' elaboration).

Information Distortions Groups		Information Distortion Characteristics (Subgroups)	IDR	
			TF	UOF
Group A_1		$A_{1.1.}$ Untrue information	$IDR =$ 0.1–2.7%	$IDR =$ 0.0–0.05%
		$A_{1.2.}$ Outdated, asymmetric, incomplete information	$IDR =$ 2.8–10%	$IDR =$ 0.05–1.2%
Group A_2		$A_{2.1.}$ Contradictory, inconsistent, ambiguous information	$IDR =$ 60–75%	$IDR =$ 1.2–5.7%
		$A_{2.2.}$ Unstructured information	$IDR =$ 75–95%	$IDR =$ 5.0–7.5%
Group A_3		$A_{3.1.}$ Information exposed to inaccuracies	$IDR =$ 95–98%	$IDR =$ 7.5–15.0%
		$A_{3.2.}$ Information exposed to spelling/stylistic errors	$IDR =$ 98–100%	$IDR =$ 15.0–30.0%

IDR—index of corrupted information file reparability; TF—traditional freight; UOF—unique/occasional freight.

4.3. Assessing the Information Distortion Impact on Decision-Making Trustworthiness

The assessment of the information distortion's impact on decision-making quality was based on the DMA modelling technique [63]. Let us set the following:

1. All information files needed to conduct the analysis are available.
2. The sets of activities and outcomes are presented in a set R^n in a way that one decision results in one outcome.
3. The results of the decision-making process could be assessed before they are implemented through its quality indicated as the experienced decision utility (EDU) measure [25]:

$$EDU(x_i) = \sum O(x_i)\{PA[O(x_i)] \times U[O(x_i)]\}, \quad (15)$$

where

x_i—information files used in the managerial decision-making process, $i = 1, 2, 3, \ldots, I$;
$O(x_i)$—the expected value set of decision-making based on the i-th information files;
$PA[O(x_i)]$—the probability of making a trustworthy decision based on the i-th information files;
$U[O(x_i)]$—the expected values of decisions based on the i-th information files.

The diagram for investigating the probability of information distortion affecting decision trustworthiness is presented in Figure 5.

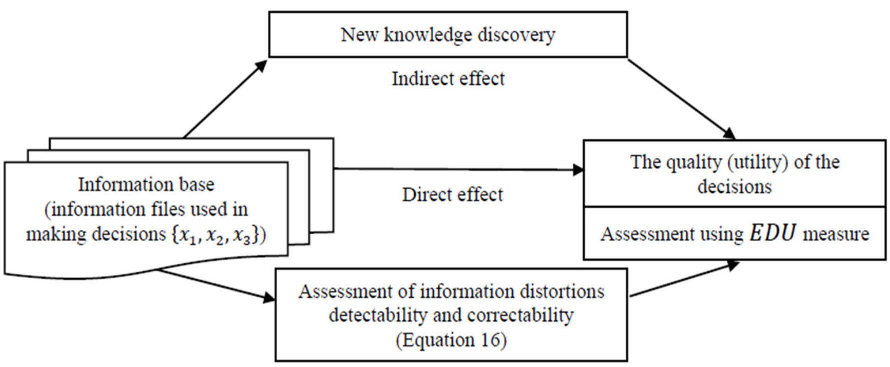

Figure 5. The diagram for investigating the probability of information distortion affecting decision trustworthiness (authors' elaboration).

Then, Martins' [64] model was applied, according to which the probability of information distortion is variable, and managers use the information collected by supplementing it with their experience. Thus, the following was established:

1. The probability of information distortion is a linear combination of both the frequency of such distortion at moment t_1 and those detected earlier in the period $[t_0, t_1]$.
2. The logic for assessing the probability of adverse events (making untrustworthy decisions) follows the Bayesian rule and depends on the managers' experience [4,72] and the detectability and correctability of distortions in the information used:

$$P(C|D) = \frac{P(D|C)\, P(C)}{P(D)}, \tag{16}$$

where

C—the activity aiming at detecting significant information distortion;
P(C)—the probability of detecting significant information distortion, $P(C) \geq 0$;
$P(D)$—the probability of an event requiring the manager to make a decision, $P(D) \neq 0$;
$P(C|D)$—the probability that activity C (striving to detect information distortion) will occur when the manager needs to make a decision (event D is non-trivially unavoidable);
$P(D|C)$—the probability that D is effective after activity C has been performed, i.e., after the information has been verified and possible distortion has been detected (action C is completed and recommended).

The practice of T&L industry companies' operations shows that the information gathered by managers to make effective decisions during LSTC planning may be partially distorted. Let us set that it belongs to the A_k-group of distortions ($k = 1, 2, 3$) from category A. Then, the following designations may be introduced:

- $P[X^*(A_k|A)]$—the probability that the verified information set X^* contains distortions of the randomly selected group (A_1, A_2, or A_3) from category A distortions;
- $P[A_k|X^*(L)]$—the probability that the verified set of information files X^* with standard length L contains distortions from the A_k group;
- $P[X^*(L)|A_k]$—the probability that the real distortions in the verified information file X^* are identical to those in the distortions group selected randomly.

Therefore, the probability that the analysed distortion group from the set $[A_1, A_3, A_3]$ will be identical to the verified file of L-length, can be calculated using Equation (17):

$$P[A_k|X^*(L)] = P[X^*(A_k|A)] \times [X^*(A_k|A)] / \sum P[X^*(A_k|A) \times [X^*(A_k|A)]]\,. \tag{17}$$

Then, the probability that the distortions in the verified information file are identical to the selected group of distortions, that is, the $P[X^*(L)|A_k]$ value is assessed.

The research algorithm is shown in Table 3.

It should be noted that the term "decision quality" is ambiguous because, firstly, it can be fully evaluated only after its implementation. Secondly, there is a risk of a radical reduction in quality depending on changes in the business environment, decision feasibility, experience of managers involved in the management process, and other aspects. Therefore, the term "decision trustworthiness" was chosen for further research, and the values of utility features determining the degree of the client's requirements fulfilment were compared. These features were divided into subsets of measurable (subject to quantifiable risk) and non-measurable (subject to non-quantifiable risk).

Research was performed for three decision groups, as follows:

- GDx_1: related to the elaboration of a transportation work schedule;
- GDx_2: related to transport route selection;
- GDx_3: related to transport process organization.

Each non-measurable decision's feature was evaluated as a probability within the interval $[0,\ 1]$. Measurable features were scored within the interval $[0, 10]$. The calculations were based on information obtained from transport companies' representatives using the questionnaire survey. Respondents were asked to provide assessments of distortions divided into abovementioned groups and subgroups for traditional and unique/occasional freight separately. The information distortions occurring during the development of the transportation work schedule, transport route selection, and transport process organization were considered. The results of calculations conducted using the developed research algorithm are shown in Table 4.

Table 3. The steps implemented in the research algorithm (authors' elaboration).

Steps	Activity Performed
Step 1	Determining measurable and non-measurable decisions' utility features
Step 2	Identifying the set of collected information distortion groups A_k; $k = \{1, 2, 3\}$
Step 3	Selection of analysed decision groups
Step 4	Sorting distortions within the subgroups according to significance (A_1, A_2, A_3)
Step 5	Evaluating the grouping accuracy according to Pearson or Spearman coefficient
Step 6	Introducing evaluation scales and scoring the alternative decision features
Step 7	Assessment EDU of the decisions $[x_1,\ x_2, x_3]$ for traditional freight transport
Step 8	Assessment EDU of the decisions $[x_1,\ x_2, x_3]$ for unique/occasional freight transport
Step 9	Assessment of the discovering new knowledge probability
Step 10	Verification: What effects (and with what probability) will arise when relying on low/high-value information in planning traditional freight transport?
Step 11	Verification: What effects (and with what probability) will arise when relying on low/high-value information in planning unique/occasional freight transport?
Step 12	Summary assessment of each distortion group's impact on decision quality

Table 4. Research results (authors' elaboration).

Distortion Groups and Subgroups		**Success Probability of the Decision-Making Process during LSTC Planning**							
		The Case of Traditional Freight				**The Case of Unique/Occasional Freight**			
		PKDD	$\frac{EDU(I)x_1}{EDU(M)x_1}$	$\frac{EDU(I)x_2}{EDU(M)x_2}$	$\frac{EDU(I)x_3}{EDU(M)x_3}$	***PKDD***	$\frac{EDU(I)x_1}{EDU(M)x_1}$	$\frac{EDU(I)x_2}{EDU(M)x_2}$	$\frac{EDU(I)x_3}{EDU(M)x_3}$
Group A_1	$A_{1.1.}$	0	$\frac{0.015}{0.985}$	$\frac{0.126}{0.874}$	$\frac{0.102}{0.898}$	0	$\frac{0.002}{0.998}$	$\frac{0.016}{0.984}$	$\frac{0.007}{0.993}$
	$A_{1.2.}$	0	$\frac{0.021}{0.979}$	$\frac{0.108}{0.892}$	$\frac{0.132}{0.868}$	0	$\frac{0.005}{0.995}$	$\frac{0.011}{0.989}$	$\frac{0.009}{0.991}$
Group A_2	$A_{2.1.}$	0.07	$\frac{0.041}{0.959}$	$\frac{0.136}{0.864}$	$\frac{0.121}{0.985}$	0.18	$\frac{0.019}{0.981}$	$\frac{0.072}{0.928}$	$\frac{0.014}{0.986}$
	$A_{2.2.}$	0.24	$\frac{0.153}{0.847}$	$\frac{0.219}{0.781}$	$\frac{0.183}{0.817}$	0.51	$\frac{0.104}{0.896}$	$\frac{0.162}{0.838}$	$\frac{0.099}{0.901}$
Group A_3	$A_{3.1.}$	0.45	$\frac{0.528}{0.472}$	$\frac{0.776}{0.224}$	$\frac{0.621}{0.379}$	0.63	$\frac{0.574}{0.426}$	$\frac{0.861}{0.139}$	$\frac{0.701}{0.299}$
	$A_{3.2.}$	0.43	$\frac{0.673}{0.327}$	$\frac{0.801}{0.199}$	$\frac{0.846}{0.154}$	0.23	$\frac{0.732}{0.268}$	$\frac{0.872}{0.128}$	$\frac{0.865}{0.135}$
Type ***B***		0.19	$\frac{0.712}{0.288}$	$\frac{0.859}{0.141}$	$\frac{0.754}{0.246}$	0.19	$\frac{0.781}{0.219}$	$\frac{0.902}{0.098}$	$\frac{0.862}{0.138}$

$EDU(I)$—the trustworthiness of decisions made solely based on information gathered, $EDU(M)$—the trustworthiness of decisions made solely based on the manager's experience and qualifications, $PKDD$—the probability of new knowledge discovery in databases.

As a result of the simulation, it was possible to assess the trustworthiness of decisions made solely based on information gathered and the trustworthiness of decisions made solely based on the manager's experience and qualifications, as well as to calculate the probability of new knowledge discovery in databases.

The decision trustworthiness was considered sufficient when its measurable feature values were higher than 0.7 points and the non-measurable features were met. The study was conducted for the weakest link of the LSTC.

5. Discussions and Conclusions

This article investigated the impact of information distortions on decision-making trustworthiness during freight land–sea transport chain planning. The information distortion categories and groups, as well as clustering rules, were identified. The impact of such distortions on decision-making quality during freight LSTC planning was assessed. A methodology for making trustworthy decisions was developed. It was possible to determine the probability of making trustworthy decisions during freight land–sea transport chain planning for both traditional and unique/occasional freight. Moreover, the set hypotheses were proved.

The research results allowed us to systemise and widen the knowledge of information distortions and their impact on decision-making quality, as well as develop theoretical methods that may be applied to solving practical tasks (Table 5).

Table 5. Testing of the proposed approach's practical usefulness (authors' elaboration).

Areas of Decision-Making	**Investigated Tasks**	**Selected Example: Analysis of Decisions Related to Ship Traffic on Modernized Świnoujście–Szczecin Fairway**			
		Test Preparation		**Test Results**	
		Information Collection	**Testing of Information Files**	**Confirmed Effect**	**Calculated Effect**
Strategic decisions	Adjusting vessel traffic to parameters of modernized fairway	Vessels' types, parameters, speeds, weather conditions, etc. (max NQR)	Comprehensive characteristics of possible ship movements on the fairway	Time-consumption reduction for information verification	11–14%
Tactical decisions	Increasing supply chain visibility	VTS information services systems (min NQR)	Complete parameters of VTS information systems	Time-consumption reduction for information verification	19–21%
Operational decisions (quick, timely)	Effective scheduling, Monitoring, and control of vessel traffic on modernized fairway	Monitoring of vessels carrying traditional freight (min NQR)	Causes and consequences of congestion on shipping routes	Time-consumption reduction for information verification	15–17%
		Monitoring of vessels carrying unique/occasional freight (max NQR)	Causes and consequences of risk factors' impact on accident occurrence		8–9%

The coincidence of different changes taking place during LSTC planning and execution [73,74] contributes to the need to improve the tools to support these chains' management. Therefore, it is important to increase the reliability of information exchange between all LSTC participants based on uniform procedures to eliminate possible distortions.

The methodology developed in the present study shows the possibility of analysing the following:

- The impact of information quality on the decisions accuracy for both logistics service integrators (LSIs) and logistics service providers (LSPs) by assessing the time adjustment of work schedules developed by LSTC subcontractors and the risk of inappropriate decisions,
- The rationality of decisions made by LSIs/LSPs based on their experience only or based on current information gathered during transport task planning.

Based on an analysis of the achieved results, it can be concluded that rapidly introduced infrastructure modernizations significantly contribute to the information uncertainty faced by managers involved in LSTC planning, who have to assess the time of both freight transportation and port handling operations. Consequently, uncertainty occurrence affects the accuracy of decisions regarding the scheduling of these activities.

This fact was the reason why the authors did not analyse the impact of information uncertainty on managerial decision accuracy in terms of quantifiable risk, assuming that it can be calculated as the multiplication of probability and consequences of wrong decisions [75]. As revealed by the literature review, this approach has been widely used in studies related to the investigation of information asymmetry's impact on managerial decisions [76,77]. According to the authors of the present study, the current practice of transport and logistics chain management, implemented under conditions of rapid infrastructural transformations, should be based on assessments of non-quantifiable risk of inappropriate decisions [78]. This approach has allowed for a comparative analysis that considers situations when LSIs/LSPs are making decisions under conditions that they have not previously faced. Examples of such situations can include market entry by new shipowners or road transport companies (e.g., due to easier access to LSTC infrastructure or easier options for purchasing transport means), as well as resignation from cooperation with a client (e.g., due to countries borders being blocked for import and/or export of certain commodity groups), etc. In the authors' opinion, in the near future, the following issues will arise:

- The problem of ensuring the high quality of information used by the decision-makers during LSTC planning and management will become increasingly important,
- The evaluation of the non-quantifiable risk of inappropriate decisions made by T&L industry companies' managers will become very significant while assessing the effectiveness of transport and logistics task management.

Based on a detailed analysis of simulation results achieved by applying the developed methodology, it can be stated that obtained probability values differ for LSTC planned for traditional and unique/occasional freight. In particular, the following conclusions may be drawn:

- The role of a manager's knowledge/experience should be emphasised for LSTC planning for traditional freight. Making trustworthy decisions based on low-value information (subgroups $A_{1.1.}$ and $A_{1.2.}$) depends on the manager's knowledge and experience, with a probability of 0.868–0.979. In this case, the probability of information's positive impact on the decision's trustworthiness is assessed as 0.015–0.132.
- The role of information value is essential for LSTC planning for traditional freight. Making trustworthy decisions based on high-value information (subgroups $A_{3.1.}$ and $A_{3.2.}/\boldsymbol{B}$) depends on the type of task being solved and the information distortion significance, with a probability of 0.673–0.902. The impact of the manager's knowledge/experience on the decision's trustworthiness is assessed as 0.141–0.471.
- The probability of discovering new knowledge for unique/occasional freight ranges from 0.00 to 0.63 and, for traditional freight, 0.00–0.45.

Based on the research results, it may be stated that the manager's ability to assess information considerably increases, especially in crisis situations, when the lack of time to verify information threatens the decision's accuracy. The reduction of distorted information in each analysed information file leads to better decision-making while organising and performing LSTC. However, it should be noted that even if most of the information received is correct (or is corrected later), the remaining single wrong but very significant information may still lead to inaccurate decisions. The presented approach may be applied to analyse linear information flows, and may be developed to manage multiple and independent information flows in parallel.

The differences in the probability of making trustworthy decisions during transport planning for traditional and unique/occasional freight should be discussed. The higher probability values were achieved for traditional freight, which is carried out based on the experience of managers, servicing, and predictive maintenance of such vehicles as light-duty trucks or various ships, e.g., general cargo ships, bulk ships, crude oil tankers ships, chemical tankers ships, and container ships. The lower probability values were achieved for unique/occasional freight hauled, e.g., by heavy-duty trucks, flatbed trucks, ballast trucks, and semi-trailers.

Moreover, this research is limited to the three decision groups that were considered in the article, including those related to the elaboration of a transportation work schedule (GDx_1), transport routes selection (GDx_2), and transportation process organization (GDx_3). In future, our investigations will cover other groups of decisions made by T&L industry enterprises.

Simulation results were achieved based on data collected using a questionnaire survey filled in by representatives of 12 selected companies. Most of these companies are located in Poland. Therefore, it would be reasonable to repeat the research and analyse the opinions of practitioners employed in T&L industry companies located in other countries, which will provide the possibility to compare the results.

The research results form the basis for software development that may be used in practice by managers from T&L industry companies both organising sustainable LSTC and making decisions based on information obtained from various sources. The application of such software could facilitate the assessment of distortions' impact on the trustworthiness of decisions for both traditional and unique/occasional freight.

It should be highlighted that the increase in business environment instability and the intensification of competition in the T&L services market impact the problem of ensuring decision-making effectiveness as key issues in the short- and medium-term perspective. Therefore, the impact of information distortions on decisions made by transport company managers, considering the time of distortions' influence, will be analysed during our future research. The authors' further research will also focus on examining the consequences of using low-value information in decision-making processes in the T&L industry.

Moreover, this study is related to the research project "Modelling of decision-making processes for the entry of seagoing and inland vessels on the Świnoujście–Szczecin fairway" financed by the Ministry of Education and Science (Poland), grant number DWD/6/0570/2022. The practical implementation of research results within this project for decision-making process improvement is considered.

Author Contributions: Conceptualisation, A.T., I.S. and L.F.-D.; methodology, I.S. and L.F.-D.; software, I.S. and L.F.-D.; validation, W.D.; formal analysis, I.S. and L.F.-D.; investigation, A.T., I.S. and L.F.-D.; resources, L.F.-D. and W.D.; data curation, A.T., I.S., L.F.-D. and W.D.; writing—original draft preparation, I.S. and L.F.-D.; writing—review and editing, A.T. and W.D.; visualisation, W.D.; supervision, A.T.; project administration, L.F.-D.; funding acquisition, A.T. and W.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research was co-financed by the Ministry of Education and Science (Poland), grant number DWD/6/0570/2022.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are contained within the article.

Acknowledgments: The authors would like to thank the representatives of T&L sector companies for taking part in the questionnaire survey.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Zhao, N.; Wang, Z.; Ji, X.; Fu, H.; Wang, Q. Analysis of a maritime transport chain with information asymmetry and disruption risk. *Ocean Coast. Manag.* **2023**, *231*, 106405. [CrossRef] [PubMed]
2. Bishop, A. How Misinformation Can Impact Businesses. 2022. Available online: https://techinformed.com/how-misinformation-can-impact-businesses (accessed on 1 July 2023).

3. Alicke, K.; Barriball, E.; Foster, T.; Mauhourat, J.; Trautwein, V.; Taking the Pulse of Shifting Supply Chains. McKinsey and Company. 2022. Available online: https://www.mckinsey.com/capabilities/operations/our-insights/taking-the-pulse-of-shifting-supply-chains (accessed on 12 June 2023).
4. Stuart, A.; Ord, K. *Kendall's Advanced Theory of Statistics, Volume I: Distribution Theory*, 6th ed.; Wiley: Hoboken, NY, USA, 1994; ISBN 978-0-470-66530-5.
5. Santos, T.A.; Fonseca, M.Â.; Martins, P.; Soares, C.G. Integrating Short Sea Shipping with Trans-European Transport Networks. *J. Mar. Sci. Eng.* **2022**, *10*, 218. [CrossRef]
6. Zhao, H.; Yu, N.; Zhu, S. International land-sea trade corridor for sustainable transportation: A review. *Clean. Logist. Supply Chain* **2023**, *6*, 100089. [CrossRef]
7. Filina-Dawidowicz, L.; Durczak, W. Organization of Vessel Traffic on Dredged Świnoujście-Szczecin Fairway: VTS Operators' Viewpoint on the Use of Infrastructure for Ships Passing. *Eur. Res. Stud. J.* **2023**, *XXVI*, 152–169. [CrossRef]
8. Jensen, A.E. Baltic Adriatic. Fifth Work Plan of the European Coordinator, European Comission. 2022. Available online: https://transport.ec.europa.eu/document/download/301f86ea-9a4a-4d71-98d3-6437e09c13d1_en?filename=5th_workplan_bac.pdf (accessed on 25 March 2024).
9. Szczecin Seaport. Statistics—Summary. The Volume of Transshipment in the Ports of Szczecin and Świnoujście by Commodity Groups in 2020—2023 [Thousands Tone]. 2024. Available online: https://port.szczecin.pl/porty/statystyki/statystyki-zbiorcze (accessed on 25 March 2024).
10. Zhu, S.; Jia, S.; Sun, Q.; Meng, Q. An empirical study of China–Singapore International Land–Sea Trade Corridor: Analysis from supply and demand sides. *Transp. Policy* **2023**, *135*, 1–10. [CrossRef]
11. Jacyna, M. Some aspects of multicriteria evaluation of traffic flow distribution in a multimodal transport corridor. *Arch. Transp.* **1998**, *10*, 37–52. Available online: https://api.semanticscholar.org/CorpusID:127366691 (accessed on 25 March 2024).
12. Jacyna, M.; Wasiak, M.; Lewczuk, K.; Kłodawski, M. Simulation model of transport system of Poland as a tool for developing sustainable transport. *Arch. Transp.* **2014**, *31*, 23–35. [CrossRef]
13. Ma, D.; Xu, C. A study of symbiotic relationships in the development of land-sea coordination systems. *ICIC Express Lett. Part B Appl.* **2017**, *8*, 1103–1109.
14. Gnap, J.; Senko, Š.; Drliciak, M.; Kostrzewski, M. Modeling of time availability of intermodal terminals. *Transp. Res. Procedia* **2021**, *55*, 442–449. [CrossRef]
15. Juhász, M.; Mátrai, T.; da Cruz, J.H.O.; Török, Á. Test Environments to Analyse Methodological Improvements of Cost-benefit Analysis for Transport Interventions. *Period. Polytech. Transp. Eng.* **2023**, *51*, 155–165. [CrossRef]
16. Trojanowski, P.; Trojanowska, J. Reliability of Road Transport Means as a Factor Affecting the Risk of Failure—The Transport Problem Case Study. In *Advances in Design, Simulation and Manufacturing IV. DSMIE 2021*; Lecture Notes in Mechanical Engineering; Springer: Cham, Switzerland, 2021; pp. 253–261. [CrossRef]
17. Paulauskiene, T.; Anne, O.; Viederyte, R.; Abele, L. Alternative solutions for marine fuel's composition towards Marine Strategy Directive performance. *IOP Conf. Ser. Earth Environ. Sci.* **2019**, *390*, 012051. [CrossRef]
18. Shen, B.; Choi, T.M.; Minner, S. A review on supply chain contracting with information considerations: Information updating and information asymmetry. *Int. J. Prod. Res.* **2019**, *57*, 4898–4936. [CrossRef]
19. Babich, V.; Li, H.; Ritchken, P.; Wang, Y. Contracting with asymmetric demand information in supply chains. *Eur. J. Oper. Res.* **2012**, *217*, 333–341. [CrossRef]
20. Cao, E.; Chen, G. Information sharing motivated by production cost reduction in a supply chain with downstream competition. *Nav. Res. Logist.* **2021**, *68*, 855–987. [CrossRef]
21. Semenov, I.; Filina-Dawidowicz, L.; Trojanowski, P. Integrated approach to information analysis for planning the transport of sensitive cargo. *Arch. Transp.* **2019**, *51*, 65–76. [CrossRef]
22. Gołebiowski, P.; Zak, J.; Jacyna-Gołda, I. Approach to the proecological distribution of the traffic flow on the transport network from the point of view of carbon dioxide. *Sustainability* **2020**, *12*, 6936. [CrossRef]
23. Boldizsár, A.; Mészáros, F.; Torok, E. Social and Economic Analysis of the EU Road Freight Transport Fleet. *Cogn. Sustain.* **2022**, *1*. [CrossRef]
24. Thomas, A.V.; Mahanty, B. Dynamic assessment of control system designs of information shared supply chain network experiencing supplier disruption. *Oper. Res.* **2021**, *21*, 425–451. [CrossRef]
25. Berridge, K.C.; O'Doherty, J.P. From Experienced Utility to Decision Utility. *Neuroeconomics Decis. Mak. Brain* **2014**, *18*, 335–351. [CrossRef]
26. Cao, Z.; Wang, Y.; Zhao, J.; Min, J. Store brand introduction and quantity decision under asymmetric cost information in a retailer-led supply chain. *Comput. Ind. Eng.* **2021**, *152*, 106995. [CrossRef]
27. Semenov, I.; Filina-Dawidowicz, L.; Możdrzeń, D. Information Distorting Impact on Deliveries Planning Efficiency. In Proceedings of the 38th International Business Information Management Association (IBIMA), Seville, Spain, 23–24 November 2021; pp. 4239–4246.
28. Jacyna, M.; Semenov, I. Models of Vehicle Service System Supply under Information Uncertainty. *Eksploat. I Niezawodn. —Maint. Reliab.* **2020**, *22*, 694–704. [CrossRef]
29. Wang, W.; Xu, Y.; Wu, Y.J.; Goh, M. Linguistic information distortion on investment decision-making in the crowdfunding market. *Manag. Decis.* **2022**, *60*, 648–672. [CrossRef]

30. Wachnik, B.; Pryciński, P.; Murawski, J.; Nader, M. An analysis of the causes and consequences of the information gap in IT projects. The client's and the supplier's perspective in Poland. *Arch. Transp.* **2021**, *60*, 219–244. [CrossRef]
31. Zieja, M.; Smoliński, H.; Gołda, P. Information systems as a tool for supporting the management of aircraft flight safety. *Arch. Transp.* **2015**, *36*, 68–76. [CrossRef]
32. Liao, L.; Yang, C.; Quan, L. Construction supply chain management: A systematic literature review and future development. *J. Clean. Prod.* **2023**, *382*, 135230. [CrossRef]
33. Chen, K.; Feng, M.; Yang, L. Information sharing for competing supply chains with demand disruption. *RAIRO-Oper. Res.* **2017**, *51*, 779–804. [CrossRef]
34. Chen, J.; Pun, H.; Zhang, Q. Eliminate demand information disadvantage in a supplier encroachment supply chain with information acquisition. *Eur. J. Oper. Res.* **2023**, *305*, 659–673. [CrossRef]
35. Valashiya, M.C.; Luke, R. Enhancing supply chain information sharing with third party logistics service providers. *Int. J. Logist. Manag.* **2023**, *34*, 1523–1542. [CrossRef]
36. Maskey, R.; Fei, J.; Nguyen, H.-O. Critical factors affecting information sharing in supply chains. *Prod. Plan. Control* **2020**, *31*, 557–574. [CrossRef]
37. Wasiak, M.; Jacyna-Gołda, I.; Markowska, K.; Jachimowski, R.; Kłodawski, M.; Izdebski, M. The use of a supply chain configuration model to assess the reliability of logistics processes. *Eksploat. I Niezawodn. Maint. Reliab.* **2019**, *21*, 367–374. [CrossRef]
38. Suifan, T.; Saa'da, R.; Alazab, M.; Sweis, R.; Abdallah, A.; Alhyari, S. Quality of information sharing, agility, and sustainability of humanitarian aid supply chains: An empirical investigation. *Int. J. Supply Chain Manag.* **2020**, *9*, 1.
39. Xue, X.; Dou, J.; Shang, Y. Blockchain-driven supply chain decentralised operations—Information sharing perspective. *Bus. Process Manag. J.* **2021**, *27*, 184–203. [CrossRef]
40. Tang, L.; Yang, T.; Tu, Y.; Ma, Y. Supply chain information sharing under consideration of bullwhip effect and system robustness. *Flex. Serv. Manuf. J.* **2021**, *33*, 337–380. [CrossRef]
41. Lee, Y.; Strong, D.; Kahn, B.K.; Wang, R. AIMQ: A methodology for information quality assessment. *Inf. Manag.* **2002**, *40*, 133–146. [CrossRef]
42. Szajna, A.; Stryjski, R.; Wozniak, W.; Chamier-Gliszczynski, N.; Królikowski, T. The Management of Digital Data Using Innovative Technologies. *Procedia Comput. Sci.* **2022**, *207*, 3143–3152. [CrossRef]
43. Filina-Dawidowicz, L.; Cernova-Bickova, A.; Możdrzeń, D.; Semenov, I.; Wiktorowska-Jasik, A.; Bickovs, D. Organization of Cargo Traffic Using Ferry Connections. *Period. Polytech. Transp. Eng.* **2022**, *50*, 279–284. [CrossRef]
44. Sundram, V.P.K.; Chhetri, P.; Bahrin, A.S. The Consequences of Information Technology, Information Sharing and Supply Chain Integration, towards Supply Chain Performance and Firm Performance. *J. Int. Logist. Trade* **2020**, *18*, 15–31. [CrossRef]
45. Zhiwen, Z.; Yujun, X.; Junxing, L.; Limin, G.; Long, W. Supply Chain Logistics Information Collaboration Strategy Based on Evolutionary Game Theory. *IEEE Access* **2020**, *8*, 46102–46120. [CrossRef]
46. Thapa, N.; Abidi, A.I.; Kumar, S. A Survey on Information Distortion of COVID19: Applying Machine Learning and Natural Language Processing. In Proceedings of the 2022 9th International Conference on Computing for Sustainable Global Development, INDIACom 2022, New Delhi, India, 23–25 March 2022; pp. 716–721. [CrossRef]
47. Qiao, R.; Zhao, L. Reduce supply chain financing risks through supply chain integration: Dual approaches of alleviating information asymmetry and mitigating supply chain risks. *J. Enterp. Inf. Manag.* **2023**, *36*, 1533–1555. [CrossRef]
48. Vosooghidizaji, M.; Taghipour, A.; Canel-Depitre, B. Supply chain coordination under information asymmetry: A review. *Int. J. Prod. Res.* **2020**, *58*, 1805–1834. [CrossRef]
49. Polman, E. Information distortion in self-other decision making. *J. Exp. Soc. Psychol.* **2010**, *46*, 432–435. [CrossRef]
50. Li, Y.; Zobel, C.W.; Russell, R.S. Value of supply disruption information and information accuracy. *J. Purch. Supply Manag.* **2017**, *23*, 191–201. [CrossRef]
51. Benavente, J.; Alonso, B.; Rodriguez, A.; Moura, J.L. Integration of Automated Vehicle Location, Fare Control, and Schedule Data for Improved Public Transport Trip Definition. *IEEE Access* **2021**, *9*, 128250–128275. [CrossRef]
52. Zheng, S.; Wang, K.; Chan, F.T.S.; Fu, X.; Li, Z.-C. Subsidy on transport adaptation investment-modeling decisions under incomplete information and ambiguity. *Transp. Res. Part B Methodol.* **2022**, *162*, 103–129. [CrossRef]
53. Bityukov, S.; Krasnikov, N.V. The Probability of Making a Correct Decision in Hypotheses Testing as Estimator of Quality of Planned Experiments. *AIP Conf. Proc.* **2004**, *707*, 455–464. [CrossRef]
54. Li, S.; Liu, Y. Risk assessment of inland water oil tankers waiting for lockage. In Proceedings of the 2nd International Conference on Internet of Things and Smart City (IoTSC 2022), Xiamen, China, 8 May 2022; Volume 12249, p. 1224935. [CrossRef]
55. Kubanova, J.; Kubasakova, I.; Poliak, M. The comparison of the risks and forwarding company performance compared to average performance in selected EU markets. *Arch. Automot. Eng. Arch. Motoryz.* **2022**, *95*, 32–52. [CrossRef]
56. Ersoy, P.; Tanyeri, M. Risk management tools in the road transportation industry with mediation and moderation analysis. *LogForum* **2021**, *17*, 555–567. [CrossRef]
57. Xia, B.; Zhang, M.; Gao, Y.; Yang, J.; Peng, Y. Design for Optimally Routing and Scheduling a Tow Train for Just-in-Time Material Supply of Mixed-Model Assembly Lines. *Sustainability* **2023**, *15*, 14567. [CrossRef]
58. Alaei, S.; Durán-Micco, J.; Macharis, C. Synchromodal transport re-planning: An agent-based simulation approach. *Eur. Transp. Res. Rev.* **2024**, *16*, 1. [CrossRef]

59. Jin, W.; He, Z.; Peng, T. A JIT part supply scheduling strategy with electric transport device between central receiving store and supermarkets in the automobile industry considering energy. *eTransportation* **2021**, *9*, 100126. [CrossRef]
60. Preiss, R.; Risk Analysis Techniques in Engineering. TÜV AUSTRIA Fachverlag. 2020. Available online: https://www.tuv-akademie.at/uploads/media/Blick_ins_Buch_Risk_Analysis_Techniques_2020_01.pdf (accessed on 10 March 2024).
61. Colicchia, C.; Creazza, A.; Noè, C.; Strozzi, F. Information sharing in supply chains: A review of risks and opportunities using the systematic literature network analysis (SLNA). *Supply Chain Manag.* **2019**, *24*, 5–21. [CrossRef]
62. Griffin, S.; Welton, N.; Claxton, K. Exploring the Research Decision Space: The Expected Value of Information for Sequential Research Designs. *Med. Decis. Mak.* **2010**, *30*, 155–162. [CrossRef] [PubMed]
63. Tubis, A.A. Digital Maturity Assessment Model for the Organizational and Process Dimensions. *Sustainability* **2023**, *15*, 15122. [CrossRef]
64. Martins, A.C.R. Probability biases as Bayesian inference. *Judgm. Decis. Mak.* **2006**, *1*, 108–117. [CrossRef]
65. Rabbi, M.; Ali, S.M.; Kabir, G.; Mahtab, Z.; Paul, S.K. Green Supply Chain Performance Prediction Using a Bayesian Belief Network. *Sustainability* **2020**, *12*, 1101. [CrossRef]
66. Kudekar, S.; Urbanke, B. Lower Bounds on the Rate-Distortion Function of Individual LDGM Codes. 2008. Available online: https://arxiv.org/pdf/0804.1697.pdf (accessed on 25 May 2023).
67. Cover, T.; Thomas, J. *Elements of Information Theory*; John Wiley & Sons: Hoboken, NJ, USA, 2012; 784p, ISBN 13 978-0-471-24195-9.
68. Giesl, P.; Hafstein, S. Review on computational methods for Lyapunov functions. *Discret. Contin. Dyn. Syst. B* **2015**, *20*, 2291–2331. [CrossRef]
69. Muślewski, L.; Bojar, P.; Woropay, M. Identification and assessment of transport systems operation quality. *Arch. Transp.* **2011**, *23*, 321–334. [CrossRef]
70. Schober, P.; Boer, C.; Schwarte, L. Correlation Coefficients: Appropriate Use and Interpretation. *Anesth. Analg.* **2018**, *126*, 1763–1768. [CrossRef] [PubMed]
71. Lee, H.; Padmanabhan, V.; Whang, S. Information Distortion in a Supply Chain: The Bullwhip Effect. *Manag. Sci.* **1997**, *43*, 546–558. [CrossRef]
72. Walker, L.J.; Gustafson, P.; Frimer, J.A. The application of Bayesian analysis to issues in developmental research. *Int. J. Behav. Dev.* **2007**, *31*, 366–373. [CrossRef]
73. Ötvös, V.; Török, Á. Measurement of Accident Risk and a Case Study from Hungary. *Period. Polytech. Transp. Eng.* **2024**, *52*, 159–165. [CrossRef]
74. Adepoju, O.O. Analysis of Constraints against Efficiency of Seaport-hinterland Logistics in Nigeria. *Period. Polytech. Transp. Eng.* **2024**, *52*, 199–208. [CrossRef]
75. Gallagher, A.J. Risk Management Classifications. 2018. Available online: https://www.gallaghermalpractice.com/blog/post/risk-management-classifications/ (accessed on 25 March 2024).
76. Brodbeck, F.C.; Kerschreiter, R.; Mojzisch, A.; Schulz-Hardt, S. Group decision making under conditions of distributed knowledge: The information asymmetries model. *Acad. Manag. Rev.* **2007**, *32*, 459–479. Available online: https://api.semanticscholar.org/CorpusID:145294823 (accessed on 25 March 2024). [CrossRef]
77. Bergh, D.D.; Ketchen, D.J.; Orlandi, I.; Heugens, P.P.M.A.R.; Boyd, B.K. Information Asymmetry in Management Research: Past Accomplishments and Future Opportunities. *J. Manag.* **2019**, *45*, 122–158. [CrossRef]
78. Sachs, R. The governance of uncertainty: How to respond to non-quantifiable risk? *Environ. Syst. Decis.* **2023**, *43*, 537–543. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.