energies

MDPI

Article

Efficiency of Telematics Systems in Management of Operational Activities in Road Transport Enterprises

Ryszard K. Miler [1], Marcin J. Kisielewski [1], Anna Brzozowska [2] and Antonina Kalinichenko [3,4,*]

1 Management and Finance Institute, WSB University in Gdańsk, Al. Grunwaldzka 238 A, 80-266 Gdańsk, Poland; rmiler@wsb.gda.pl (R.K.M.); mkisielewski@wsb.gda.pl (M.J.K.)
2 Faculty of Management, Business Informatics and Ecosystems, Czestochowa University of Technology, ul. J.H. Dąbrowskiego 69, 42-201 Częstochowa, Poland; annabrzozowskapcz@gmail.com
3 Institute of Environmental Engineering and Biotechnology, University of Opole, Kominka Street, 6, 45-032 Opole, Poland
4 Department of Information System and Technology, Poltava State Agrarian Academy, Skovorody 1/3, 36003 Poltava, Ukraine
* Correspondence: akalinichenko@uni.opole.pl; Tel.: +48-787-321-587

Received: 29 July 2020; Accepted: 15 September 2020; Published: 18 September 2020

Abstract: Implemented in road transport enterprises (RTEs) on a large scale, telematics systems are dedicated both to the particular aspects of their operation and to the integrated fields of the total operational functioning of such entities. Hence, a research problem can be defined as the identification of their efficiency levels in the context of operational activities undertaken by RTEs (including more holistic effects, e.g., lowering fuel/energy consumption and negative environmental impacts). Current research studies refer to the efficiency of some particular modules, but there have not been any publications focused on describing the efficiency of telematics systems in a more integrated (holistic) way, due to the lack of a universal tool that could be applied to provide this type of measurement. In this paper, an attempt at filling the identified cognitive gap is presented through empirical research analysing the original matrix developed by the authors that refers to the efficiency rates of organisational activities undertaken by RTEs. The purpose of this paper is to present a tool that has been designed to provide a holistic evaluation of efficiency of telematics systems in RTE operational management. The results are presented in a form of an individual (ontogenetic) matrix of the analysed companies, for which a determinant was calculated with the use of Sarrus' rule. Obtained in such a way, the set of values identified for the determinants of the subsequent ontogenetic matrices came as an arithmetic progression that characterised the scope and the level of the influence exerted by the implemented IT (information technology) systems on the organisational efficiency of operational activities undertaken by the analysed RTEs. We present a hypothesis stating that the originally developed matrix can be viewed as a reliable tool used for comparative analysis in the field of efficiency of telematics systems in RTEs, and this hypothesis was positively verified during the research. The obtained results prove the significant potential for the wide application of the discussed matrix, which can be used as a universal tool for the analysis and comparison of efficiency indicated by the integrated IT systems in the operational activities undertaken by RTEs.

Keywords: road transport enterprises (RTEs); telematics systems; operational activities of RTEs; a universal matrix of efficiency rates

1. Introduction

Undoubtedly, problems related to the organisational behaviour of road transport enterprises (RTEs) come as a group of highly dynamic issues because RTEs face numerous functional and operational problems in the contemporary transport market [1], along with challenges related to competitiveness [2] (including economical approach) and the pursuit of process optimisation [3] (including fuel/energy efficiency). Hence, interest in all types of solutions that can be helpful in facing decision-making challenges in the field of management has been growing [4–6], and more efficient and more effective operation strategies [7], especially in the field of operational activities, have been researched [8,9]. A remedy to the above-mentioned problems may be found in the application of managerial information technology (IT) systems [7] (more broadly understood as telematics systems) [10,11], the functionalities of which are dedicated to the current handling of transport processes (including vehicle mileage record systems, users, contractor costs, generated costs, and energy/fuel consumption) [12]. Through the use of IT systems, there is also a possibility to optimise transport routes [13–15] and to utilise work factors (such as vehicle fleet [16] load capacity and drivers' working time) [17], especially in cases where there are no regular routes due to constant changes with customer orders [18,19].

When considered in this way, the features of RTE management with the use of IT systems are the reason for a continuous discussion between the practitioners (managerial staff) and theoreticians of management about their significance, roles, and efficiency in the process of making decisions aimed at the improvement of the efficiency of the operational functioning of enterprises [20–22] in regard to economy, energy, and the environment.

The above-mentioned findings motivated the authors to undertake the research presented in this paper. The research was intended to provide an unambiguous answer to the following question: how can one indicate a correlation between the implementation of telematics systems (as tools applied by RTEs to support their operational management) and the efficiency of these entities in the competitive market while considering the scarcity of generally available theoretical analysis and the lack of a synthetic tool (rate) for indicating and measuring the expected correlation?

An in-depth analysis of specialist literature [23–25] indicated that despite some publications on the improvement in efficiency observed at various organisations, the significance and role of IT systems in increasing organisational efficiency have been relatively scarcely discussed [26]. Most frequently, such considerations have been side-effects resulting from major discussions on other problems [3,27–29].

Moreover, in light of the research on RTEs, current publications on the operational efficiency of RTEs have mostly presented the results of research based on an analysis of efficiency referring to individual factors, such as the efficiency of drivers' working time management [30], the efficiency of using the mileage (using the loading capacity) [31], and the efficiency of forwarders' work [32,33].

A scarce number of publications have indicated that there is a relationship between the implementation of IT applications (dedicated to either functional or operational fields) and an increase in the efficiency observed in the particular operational field, e.g., the implementation of electronic tachographs and the more efficient use of drivers' working time [34,35]. However, there have not been publications focused on the comprehensive influence of the integrated implementation of IT systems (more than two modules) on the organisational efficiency of RTEs. Additionally, no universal tool that could be treated as an objective measure of the influence or correlation between the implementation of IT systems and changes (expected increase) observed in the operational efficiency of RTEs has been designed.

Furthermore, despite the fact that there are some considerable knowledge deficiencies in reference to the relationships between IT systems and the organisational efficiency [36] of RTEs, some considerable investments into IT systems are made every year.

Therefore, the statement that problems related to the efficiency of RTE functioning with the use of IT systems are still serious challenges to scientific research is a well-justified one. The results of empirical research on the above-mentioned problems are presented in this paper, and these can fill the cognitive and pragmatic (instrumental) gaps observed in the discussed field.

The main objective of the research was to indicate the relation between the application of IT systems to support management (or, in a broader sense, telematics systems) and the organisational efficiency of operational activities [37] undertaken by RTEs.

The pragmatic aim of the paper is to indicate the usefulness of a matrix that has been originally developed to provide a holistic evaluation of the above-mentioned relationship, regarding the operational efficiency of RTEs. The authors formulated a general hypothesis stating that the originally developed matrix can be viewed as a reliable tool for comparative analysis in the field of the efficiency of telematics systems in RTEs. The scope of the research included RTEs (more specifically, the field of their operational activities supported by the applied IT systems).

The research was divided into three stages. During the first stage, based the information obtained with the use of the CATI (computer-assisted telephone interviewing) method [38], the key fields of operational activities undertaken by RTEs, which are the most sensitive to the implementation of telematics systems, were identified. As a result, an original matrix of the organisational efficiency rates of operational activities was developed. The above-mentioned rates were determined by the implementation of IT systems in RTEs. During the second stage, eight RTEs were identified with the use of qualitative methods, such as the individual PAPI (paper and pen personal interviews carried out with the members of the managerial staff) and questionnaire method [39,40]. The selected RTEs met the criteria adopted in the research. Additionally, an empirical analysis of the basic rates and measures of the operational activity evaluation was conducted. As a result, a graphical presentation of the outcomes recorded before and after the implementation of IT systems is provided here. During the third stage of research, an evaluation of the usability of the suggested matrix for the holistic and comparative assessment of the influence exerted by telematics systems on the efficiency of operational processes of RTEs was conducted.

Considering the results obtained during the research, the authors hope that, in the theoretical aspect, the paper will become a starting point for further research into the positive correlation between the implementation of IT systems within the pragmatics of RTE operation and the increase in operational efficiency of particular RTEs. Considering economic practice, the ontogenetic matrix may become a universal tool to support managerial decisions made at the RTE operational level (after evaluation that will be provided during further research and a pilot programme).

2. Efficiency in Transport Services (With Use of Managerial IT Systems)

Efficiency is treated as a category superior to notions such as capability, profitability, productivity, effectiveness, agility, and rationality [41]. When considering such an approach, efficiency can be understood as the relationship between effort and effect [42], the capability for agile adjustments to changes, a criterion related to the abilities of an organisation to achieve its aim [43] and to implement its strategies [44], and a tool applied to measure effective operation and efficacy [45].

In the theory of management, the notion of organisational efficiency [46] is defined as the ability of a system for current and strategic adjustment to changes in the environment, as well as the productive utilisation of resources (including fuel/energy) in order to achieve the assumed structure of targets [47]. The components of organisational efficiency are managerial [48] and technical efficiency [49]. Technical efficiency refers to the efficiency of technology and to the scale of its application.

The axiomatic approach to the transport market makes it possible to prove that a fundamental unit responsible for organising transport operations is an RTE that undertakes its operational activities (transport processes and services) [50,51] and evaluates them from the perspective of its organisational efficiency.

The operational activities of RTEs involve activities that are strictly related to the provisions of transport services, the main element of which is the implementation of transport production processes [52], which involve the use and productivity of human resources, as well as technical and other materials such as fuel/energy.

Hence, the fundamental efficiency requirement for RTEs and the effectiveness of the transport process itself is the efficiency of transport processes [53], which can be indicated with the use of various rates. The rates that are most frequently used in the evaluation of operational efficiency of RTEs include those of the technical readiness of the vehicle fleet, vehicle fleet exploitation, roadworthy vehicle exploitation, the average daily time of vehicle operation (the number of vehicle working hours per day), using the vehicle fleet operating time, the average loading capacity of vehicles in operation, the average operating speed, using the mileage, and using vehicle loading capacity or the rate of fuel consumption [54,55].

Managerial efficiency mainly involves evaluating the levels and efficiency of decisions made by the managerial staff that directly affect the operational efficiency of a particular RTE [56,57] in regard to using human resources, knowledge, and know-how, as well as the technical and operational exploitation of transport means. Consequently, the operational efficiency of an RTE affects the way in which it is perceived by its potential customers and its competitive position [58,59]. At this point, we should refer to such evaluation rates as the manager's decision-making competences and decision area, the time of the decision-making process, the scope of instrumental/systemic support (e.g., IT technologies), and the correctness of decisions (based on the evaluation systems and theory of decisions) [50].

Within the research aims of this paper, the most interesting concept is technical efficiency, which involves the efficiency of technology and its applied scale. The authors believe that the above-mentioned concept refers not only to strictly technical problems [60]—such as rates of vehicle quality, the technical condition of the vehicle fleet, operation issues, service life, vehicle technical inspections, vehicle inspection management, and compatibility with innovative transport technologies (e.g., bimodal transport) [61,62], including the effect of the scale of the applied technologies—but also to technology that supports the first component of operational efficiency, namely the managerial efficiency of RTEs. IT technologies that have been implemented (telematics systems of road transport) and the scale of their application (the integration level of the fields covered by the operational activities of RTEs), which determine the increase in the efficiency of decisions made in a particular company, directly refer to the notion of the technical efficiency of RTEs, although they are applied as technical support provided to the processes of managerial decision-making (in the field of managerial efficiency) [2,63,64].

Taking the current high complexity of transport processes [65–68] into account, it can be said that the efficient functioning of RTEs depends on the use of IT systems, including integrated IT systems (IITSs). For the requirements of the research, a taxonomy of IT systems is provided in Figure 1, with the consideration of the following division:

(a) Telematics systems—intelligent systems of road transport (ITS—intelligent transport systems) [69].
(b) Systems of transport, fleet, and transport operation management (TMS/FMS—transport/fleet management systems).

In order to achieve the main objective of the research and to properly verify the assumed hypothesis (general and partial, detailed for each stage of research), the field of the research was identified in detail, along with the required tools and expected results. The field of research includes road (freight) transport enterprises; the pragmatics of organisational efficiency, methods, and tools applied to increase the organisational efficiency in these enterprises in the field; and their operational activities, with consideration of the following parameters:

(a) The Polish road transport enterprises met the following parameters:

- They had over 9 employees classified to the H section of Transport and Warehousing, according to the Polish Classification of Business Activities (due to the assumption that a very small RTE might not implement IT services for drivers' working time management or may not implement any IT solutions).
- They had a fleet of more than 6 vehicles during the first stage of research (due to the assumption that a very small RTE might not implement IT services for fleet and order management).
- They had a fleet of more than 50 vehicles during the second stage of research (due to the assumption that the effect of the scale of IITS implementation will be assured).
- They had implemented IT/IITS systems.

- They provide transport services to the countries in Western Europe (Germany-bound as the most frequent direction) during the second stage of research (due to the assumption that the effect of the scale of IT systems for drivers' working time management implementation will be assured).

(b) The scope of the efficiency category: organisational efficiency (economic efficiency as a complementary field).

(c) Temporal: the years 2011–2016.

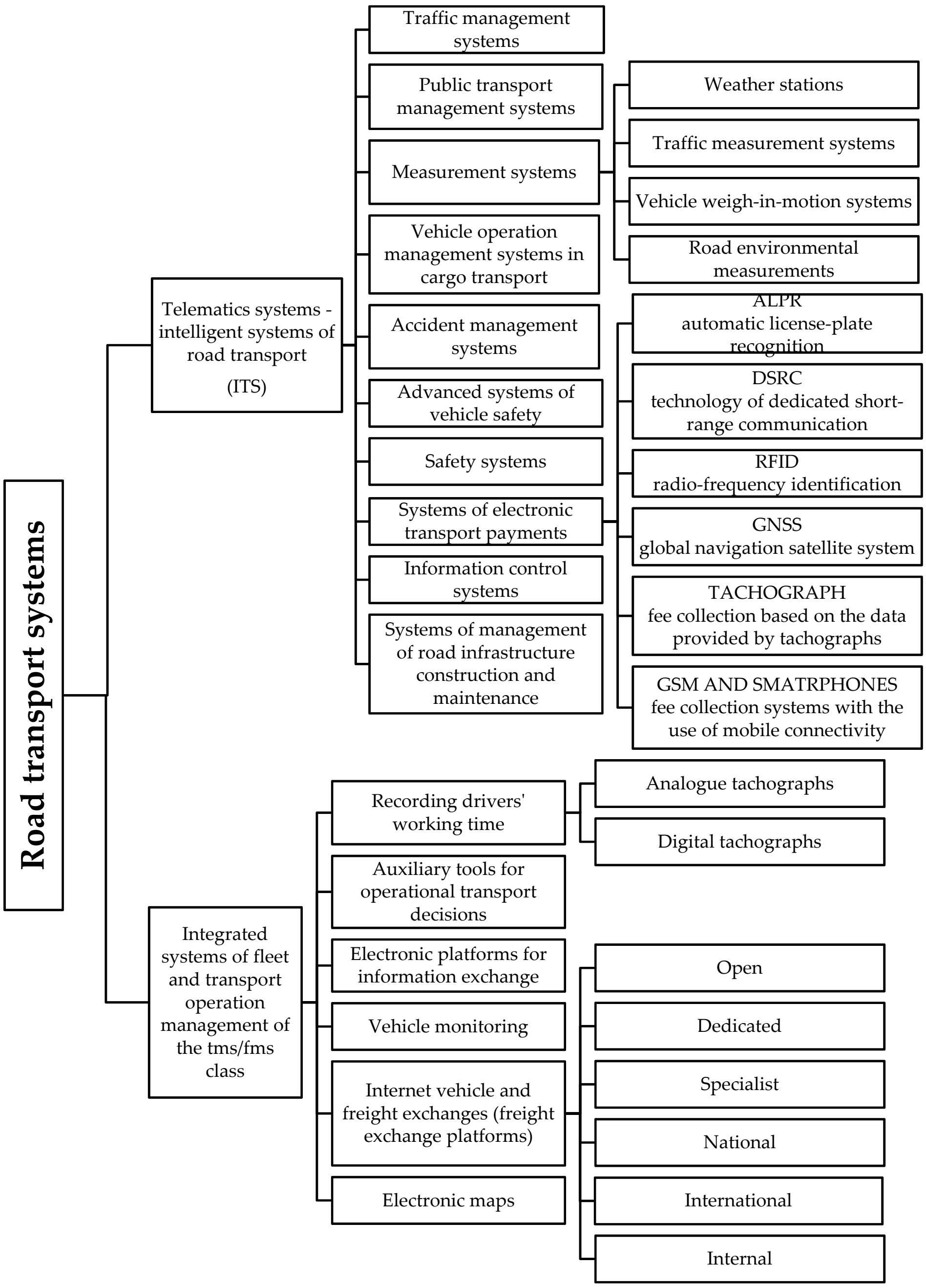

Figure 1. IT (information technology) systems supporting operation of road transport.

The main aim during the first stage of the empirical research was the identification of areas related to operational activities undertaken by RTEs that are the most sensitive to support provided by IT processes/systems (implemented in order to improve organisational efficiency). During this stage of research, the method of random choice was applied with the use of a random number generator. In reference to the terminology applied by the Central Statistical Office [70], the enterprises were selected in accordance with the following rules:

(a) The parameters of the analysed population were that the Polish RTEs had to have more than 9 employees and a fleet consisting of more than 6 vehicles (as presented in Table 1)—according to the data of 2014, the population included 3969 entities.
(b) For statistical research, we identified a population consisting of 500 RTEs at a confidence interval of 95%, a size of 0.5, and a maximum error at the level of 5% (the Infobrokering database system was used [71]).

Table 1. Enterprises (employing more than 9 drivers) operating in the sector of commercial road transport, as organised by the number of owned trucks/lorries and road tractor units.

Total	Enterprises with the Number of Lorries and Road Tractors					
	6 or Less	6–9	10–19	20–49	50–99	100 or More
2014						
3969	276	673	1839	910	188	83
2015						
3989	277	582	1860	981	191	98

Source: Transport drogowy w Polsce w latach 2014 i 2015, GUS, on-line version: http://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/transport/transport-drogowy-w-polsce-w-latach-2014-i-2015,6,4.html.

There were 356 answers provided via the questionnaire survey carried out with the CATI method; therefore, according to the sampling calculations, the condition of a representative sample was met (minimum 350 respondents) for the adopted assumptions.

The obtained results made it possible to identify the areas of operational activities undertaken by RTEs that are considered by the managerial staff of these entities as the most sensitive and the most important in terms of the support provided by IT systems to improve organisational efficiency. The results obtained during this stage of research are presented in Figure 2.

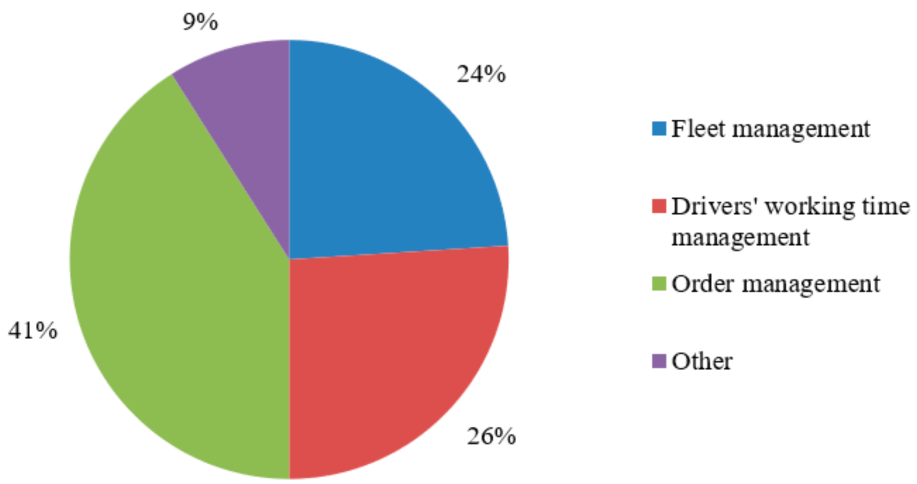

Figure 2. The fields of operational activities undertaken by the analysed enterprises that prove to be the most sensitive in terms of the support provided by IT systems.

While searching for an answer to the question how—in a holistic aspect (minimum 60% of operational activities)—an integrated IT system can affect organisational efficiency [72,73], an original matrix of rates was developed, as there have not been any other universal tools available so far.

The matrix refers to three key fields of operational activities undertaken by RTEs (fleet management [74], drivers' working time management [75], and transport order management). For each of the above-mentioned fields, three representative rates were identified, and these were included in the nine-element matrix (Figure 3). All rates included in matrix were chosen as being the most capable rates in terms of possible influence on RTE's operational efficiency, as well as being the most popular rates used in operational evaluation in RTEs by management (the most accessible rates calculated by all RTEs in the same way—convenient for any type of comparison).

		KEY FIELDS		
		Fleet management	Drivers' work management	Transport order management
KEY RATES AND MEASURES	Implemented in the integrated systems at the general level	Rate of technical readiness (A_t)	Using the driver's working time (T_{jk})	Number of daily orders per a forwarder (L_{zs})
	Implemented in the integrated systems at the operational level	Rate of using roadworthy vehicles (A_{gt})	Number of kilometres covered by one driver (K_{jp}) and by a team of drivers (K_{jz})	Number of kilometres per one order (L_{kmz})
	Implemented in the integrated systems at the specific level and/or in the dedicated systems	Rate of using the mileage of the vehicle fleet (B)	Vehicle loading time (T_{za}) and vehicle unloading time (T_{ro})	Average lead time (T_{pz})

Figure 3. Matrix of rates indicating the organisational efficiency of the operational activities undertaken by road transport enterprises (RTEs), as determined by the implementation of IT systems.

In the light of the above-mentioned findings, it was possible to formulate the main hypothesis of the stage 1 that the comprehensive use (over 60%) of IT systems in road transport enterprises improves the efficiency of their functioning by increase in their organisational efficiency in the field of their operational activities. The matrix of rates presented in the study can inform one regarding the scale of the influence exerted by IT systems on the efficiency of RTEs.

In conclusion, at this stage of research, an original matrix of the organisational efficiency rates of operational activities was developed as a necessary tool for research stage II.

3. The Course and the Results of the Research—Stage II (Rate Analysis)

The development of the rate matrix allowed the authors to reach the next stage of the empirical research aimed at the acquisition of more specific information related to the organisational efficiency of operational activities undertaken by RTEs in reference to the selected technical, technological, and economic parameters with the use of the individual questionnaire interview method (PAPI). The application of the PAPI method allowed the authors to collect quantitative and qualitative information about the analysed entities, and this information was indispensable for further research.

The main aim of the second stage of the empirical research was the evaluation of interdependencies and conditions related to the influence exerted by IT/IITS systems on the organisational efficiency of operational activities undertaken by RTEs. Based on the database used in the previous stage of research, a non-probability selection of the RTEs was conducted. From twenty-six selected RTEs (fulfilling research stage II conditions), only eight enterprises accepted an invitation to the next stage of research (for the requirements of the research and in order to anonymise as a prerequisite for participation in further research, they are labelled as A, B, C, D, E, F, G, and H), and they became the subjects of the focus research in the second part. The selected RTEs:

- Declared the implementation of the IT/IITS systems in the identified fields in 2013 (considering the fact that the implementation of the IT systems took place in various months, the data of 2013 were not included in the research because of their low usability for the assumed research aims), with a possibility of accessing the quantitative data of 2011–2012, which was the period before the implementation the discussed systems, and 2014–2016, which was the period after the implementation of these systems.
- Provided services of international (Germany-bound) transport; as such, the limitation to only one direction of transport services was justified when considering the possibility of comparing operational parameters observed in the same conditions—the choice of that destination came from the fact that almost every Polish RTE providing international transport services offers their services in that direction.

Based on the data obtained during the empirical research, a calculation of the selected organisational efficiency rates for RTE management before and after the implementation of IT/IITS systems was provided.

In the field of fleet management, the following rates were analysed:

(a) A_t—rate of technical readiness.
(b) A_{gt}—rate of using roadworthy vehicles.
(c) B—rate of using the mileage of the vehicle fleet.

The value of the technical readiness rate is highly significant for the operation of a road transport enterprise when considering its fundamental task, namely providing transport services. As seen in Figure 4, before the implementation of IT systems, the value of the discussed rate reported by four enterprises, A, B, D, and G, indicated a decreasing tendency, C and H indicated a slight increase, and E and F indicated a growing tendency.

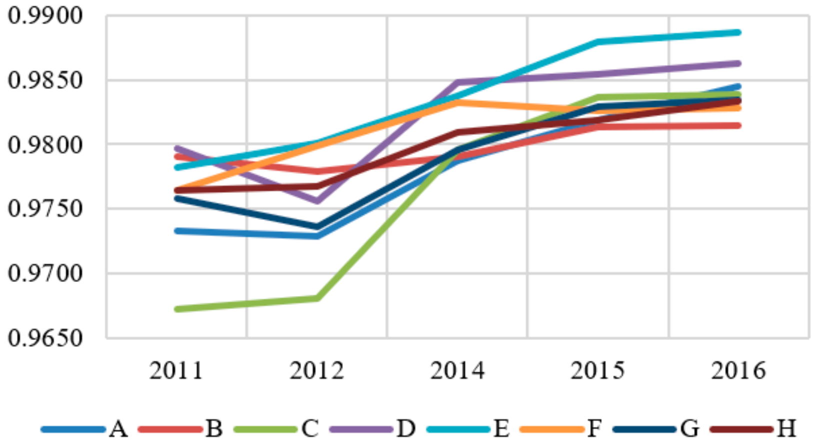

Figure 4. The average value of the technical readiness rate for the analysed road freight transport enterprises in the years 2011–2016.

The next rate, which defines the level of using roadworthy vehicles, was calculated based on the obtained data (Figure 5).

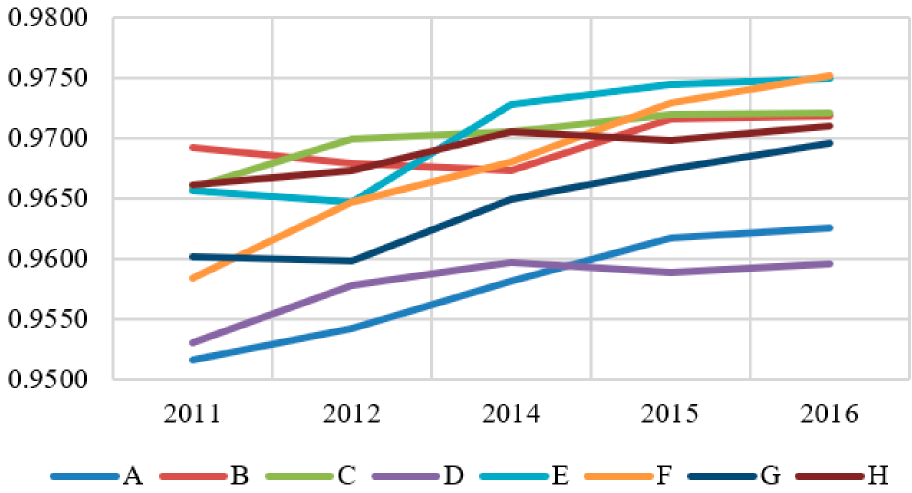

Figure 5. The average value of the using roadworthy vehicles rate for the analysed road freight transport enterprises in the years 2011–2016.

The using the mileage of the vehicle fleet rate is the relationship between the mileage covered by a vehicle with the cargo and the total mileage. However, the discussed distance must be augmented by a distance covered by the vehicle while driving from its depot base to the cargo loading point and a distance covered after the delivery of the cargo or a distance covered to reach another cargo loading point. It is possible to decrease the number of kilometres covered during empty running by the proper organisation of routes. This can be achieved with the use of relevant functions offered by IT systems. The values of the discussed rate in the analysed enterprises during the analysed period of time are presented in Figure 6.

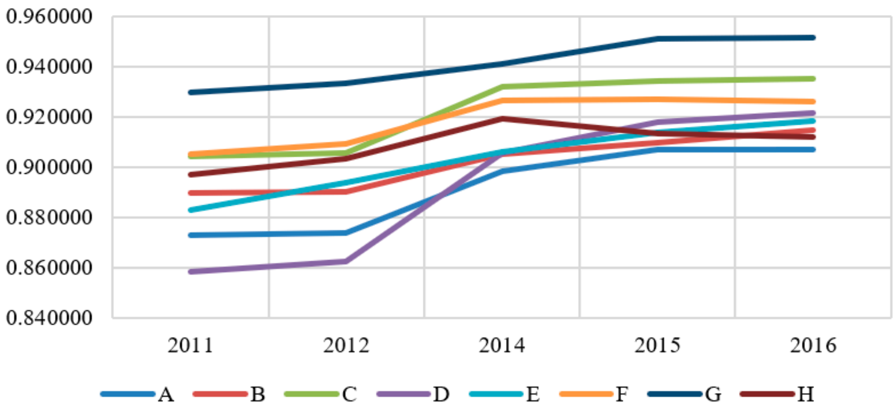

Figure 6. The average value of the using the mileage of the vehicle fleet rate for the analysed road freight transport enterprises in the years 2011–2016.

The next field that was analysed refers to the management of drivers' work. There are three representative rates in the discussed area:

(a) T_{jk}—using the driver's working time.
(b) K_{jz}—the number of kilometres covered by a team of drivers (two drivers).
(c) T_{zr}—the total time of vehicle loading and unloading.

After analysing the using the driver's working time rate (Figure 7), it was possible to state that its value has increased (by 5% on average) since IT system implementation in all the analysed cases.

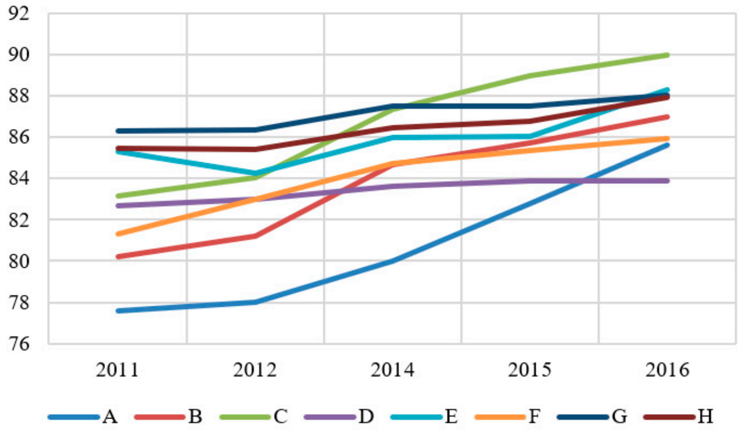

Figure 7. The average value of the using the driver's working time rate (%) for the analysed road freight transport enterprises in the years 2011–2016.

The next rate, which refers to the number of kilometres covered by a team of drivers (Figure 8), was increased by, on average, 15%.

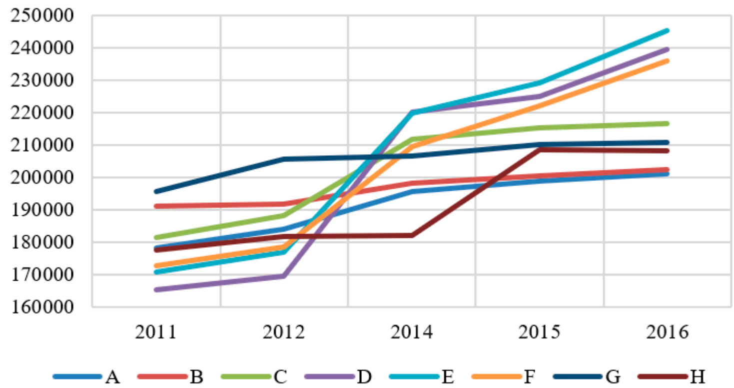

Figure 8. The average value of the annual number of kilometres covered by a team of drivers' rate (km) in Germany-bound transport for the analysed road freight transport enterprises in the years 2011–2016.

Between 2012 and 2016, the cargo loading time in the analysed enterprises was shortened by an average of 71 min. This indicated an average decrease of approximately 30% (Figure 9).

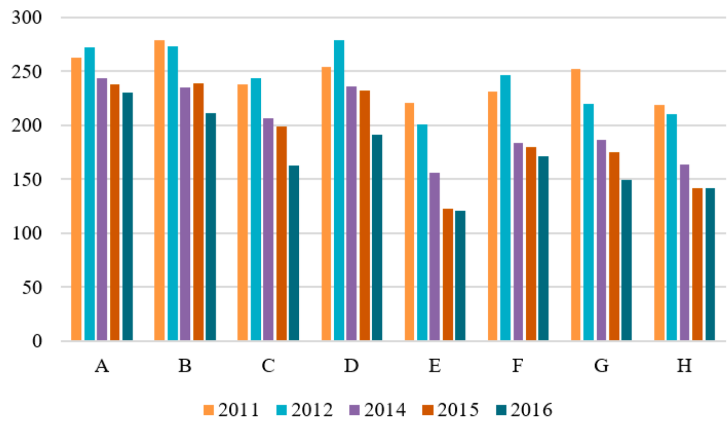

Figure 9. The average value of the vehicle loading time rate (minutes) in the analysed road freight transport enterprises in the years 2011–2016.

The next rate is related to the time of unloading a vehicle. It indicated a tendency similar to the previously discussed rate, namely that it has been considerably decreasing since 2014. In the time period between 2012 and 2016 in the analysed enterprises, the unloading time was shortened by an average of 55 min, or 30% (Figure 10).

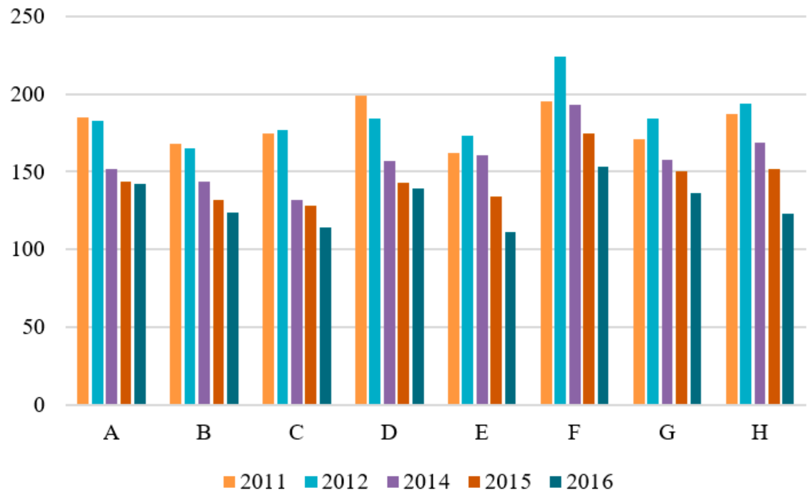

Figure 10. The average value of the vehicle unloading time rate (minutes) in the analysed road freight transport enterprises in the years 2011–2016.

The last analysed field at this stage of research was transport order management. The following rates were analysed:

(a) L_{zs}—the number of daily orders per a forwarder.
(b) L_{kmz}—the number of kilometres per one order.
(c) T_{pz}—the average lead time.

In order to increase the scope of its operational activities, an enterprise needs a proper number of transport orders. Each forwarder must gain a certain number of orders to provide profitability to their enterprise. The rate of the average number of transport orders per a forwarder in the Germany-bound transport (Figure 11) increased by three transport orders, which is by 27%, on average in all the analysed enterprises since the implementation of the IT systems.

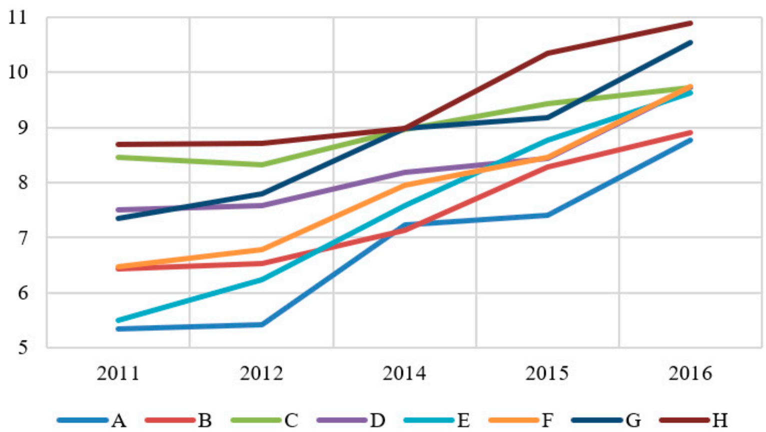

Figure 11. The average number of transport orders per day, received by a forwarder in the Germany-bound transport in the analysed road freight transport enterprises in the years 2011–2016.

The analysis of the number of kilometres per one transport order (Figure 12) indicated an average increase of 13% in the discussed enterprises.

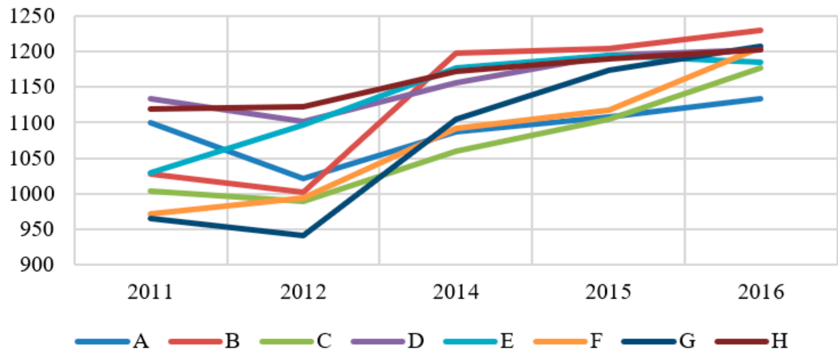

Figure 12. The average value of the rate of number of kilometres per one transport order in the Germany-bound transport in the analysed road freight transport enterprises in the years 2011–2016.

The time of making a decision about fulfilling an order in the analysed enterprises between 2012 and 2016 indicated an average decrease of 40% (Figure 13).

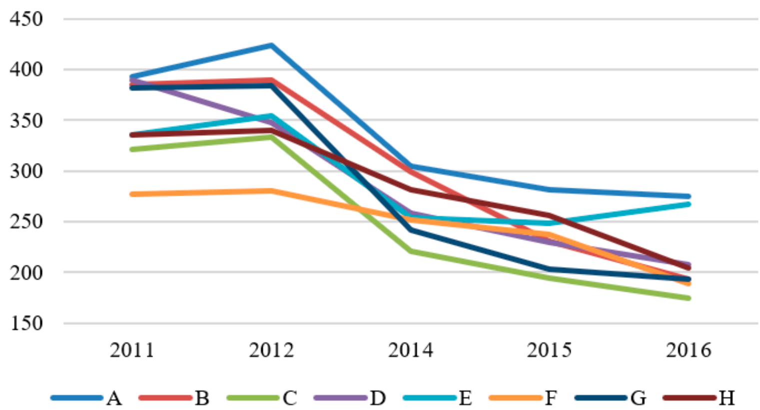

Figure 13. The average value of the rate indicating the time (minutes) required by a forwarder to make a decision about fulfilling an order in the Germany-bound transport in the analysed road freight transport enterprises in the years 2011–2016.

The results obtained during the first and the second stages of the research allowed the authors to provide an analysis with the use of an original matrix of rates that indicates the organisational efficiency of operational activities undertaken by RTEs, as determined by the implementation of IT systems. The matrix was applied as a universal tool to provide holistic and comparative analysis.

4. The Course and the Results of the Research—Stage III (Comparative Analysis with the Use of the Matrix)

During this stage of research, the results of the calculations provided during the second stage were collated in the form of an individual (ontogenetic) matrix for each of the analysed enterprises; the elements of the matrix are the calculated values of the parameters (rates and measures), and the values of the time rates (decrease in the time of the particular operations) are presented as absolute values. The main aim of this stage was to find an aggregated parameter of the comparative evaluation, which was a determinant of the individual rate matrix for each of the analysed enterprises (calculated with the use of Sarrus' rule [76]). The algorithm of the research process is presented in Figure 14.

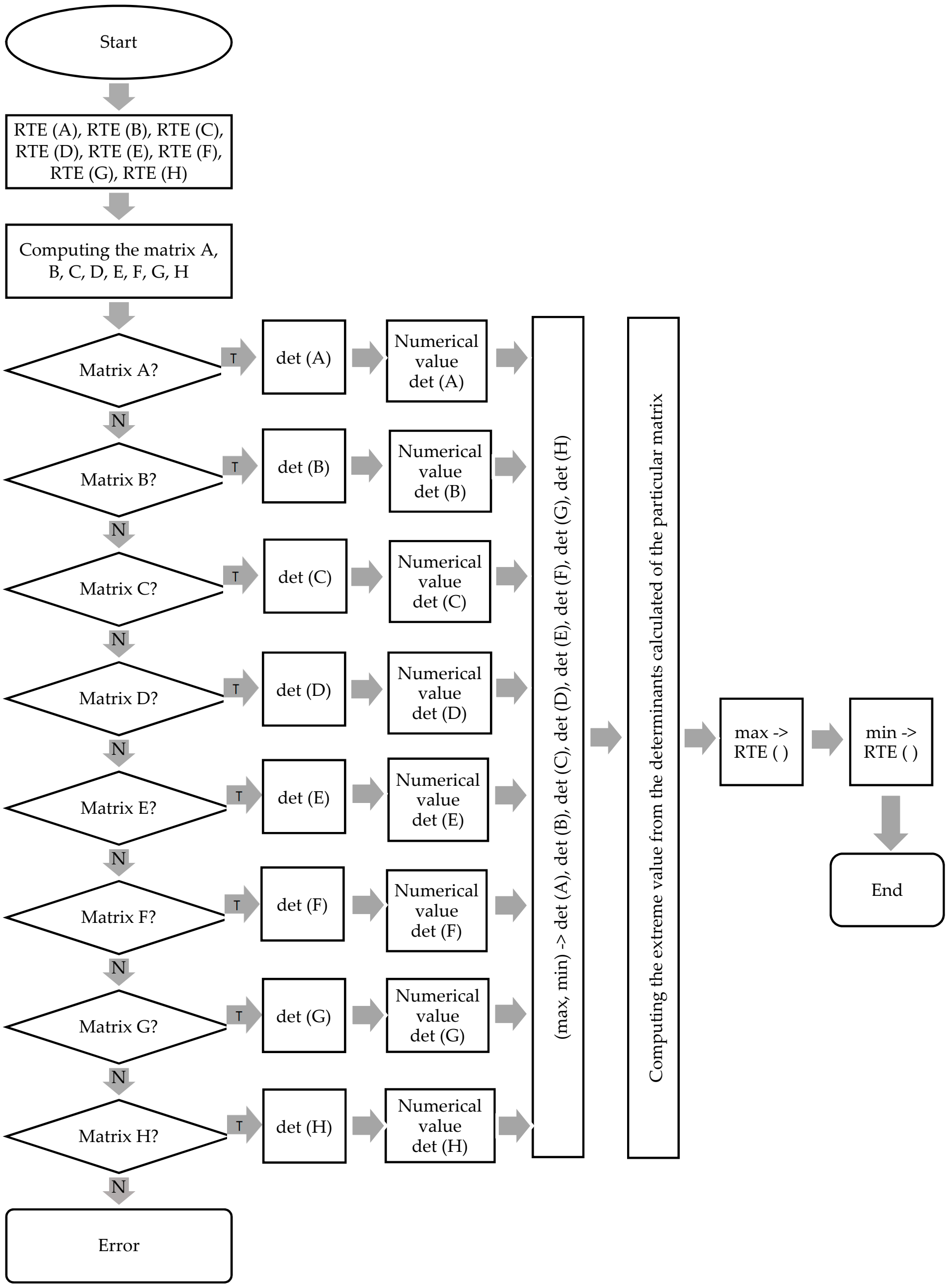

Figure 14. The algorithm for determining the researched RTEs with the highest and the lowest numerical values of the matrix determinants.

The research procedure for the development of individual (ontogenetic) matrices for each of the analysed RTEs was as follows:

- For each of the analysed enterprises, an ontogenetic matrix was developed in the following form:

$$A = \begin{bmatrix} A_t & T_{jk} & L_{zs} \\ A_{gt} & K_{jz} & L_{kmz} \\ B & T_{zr} & T_{pz} \end{bmatrix} \quad (1)$$

where A_t is the rate of technical readiness, A_{gt} is the rate of using roadworthy vehicles, B is the rate of using the mileage of the vehicle fleet, T_{jk} indicates using the driver's working time, K_{jz} is the number of kilometres covered by a team of drivers, T_{zr} is the time required for loading and unloading a vehicle, L_{zs} is the number of daily transport orders per a forwarder, L_{kmz} is the number of kilometres per one transport order, and T_{pz} is the average lead time.

- A matrix for RTE A in accordance with the values of rates and measures calculated in the previous stage of research was as follows:

$$\det(A)\begin{vmatrix} 0.0115 & 8 & 3,35 \\ 0.0084 & 17100 & 112 \\ 0.033426 & 42 & 149 \end{vmatrix} \quad (2)$$

- Calculation of the value of the determinant for the RTE A with the use of Sarrus' rule is:

det (A) = 27,353.064366

- The above-mentioned steps were repeated to develop ontogenetic matrices for RTEs B–H, as follows:

$$\det(B) = \begin{vmatrix} 0.035 & 6 & 2,39 \\ 0.0039 & 10596 & 227 \\ 0.024460 & 52 & 197 \end{vmatrix} \quad (3)$$

$$\det(C) = \begin{vmatrix} 0.018 & 6 & 1,41 \\ 0.0022 & 28488 & 188 \\ 0.029678 & 72 & 159 \end{vmatrix} \quad (4)$$

$$\det(D) = \begin{vmatrix} 0.0106 & 1 & 2,14 \\ 0.0018 & 69900 & 102 \\ 0.058992 & 67 & 140 \end{vmatrix} \quad (5)$$

$$\det(E) = \begin{vmatrix} 0.0084 & 4 & 3,4 \\ 0.0103 & 68556 & 89 \\ 0.024543 & 71 & 87 \end{vmatrix} \quad (6)$$

$$\det(F) = \begin{vmatrix} 0.0029 & 3 & 2,97 \\ 0.0104 & 57444 & 211 \\ 0.016589 & 74 & 91 \end{vmatrix} \quad (7)$$

$$\det(G) = \begin{vmatrix} 0.0098 & 2 & 2,75 \\ 0.0098 & 4956 & 267 \\ 0.018282 & 60 & 191 \end{vmatrix} \quad (8)$$

$$\det(H) = \begin{vmatrix} 0.0066 & 3 & 2,18 \\ 0.0037 & 26676 & 81 \\ 0.008630 & 70 & 136 \end{vmatrix} \quad (9)$$

Finally, the determinants of the ontogenetic matrices for the analysed RTEs B-H, provided with the use of Sarrus' rule, have been calculated as follows:

- The value of the determinant for RTE B was 72,056.0336096.
- The value of the determinant for RTE C was 70,176.29874576.
- The value of the determinant for RTE D was 94,840.805556.
- The value of the determinant for RTE E was 45,526.1574408.
- The value of the determinant for RTE F was 12,293.91095648.
- The value of the determinant for RTE G was 8878.11541.
- The value of the determinant for RTE H was 23,406.2414516.

The obtained numerical values of the matrix determinants for the particular analysed RTEs (A–H) is presented in Figure 15 as an increasingly ordered sequence.

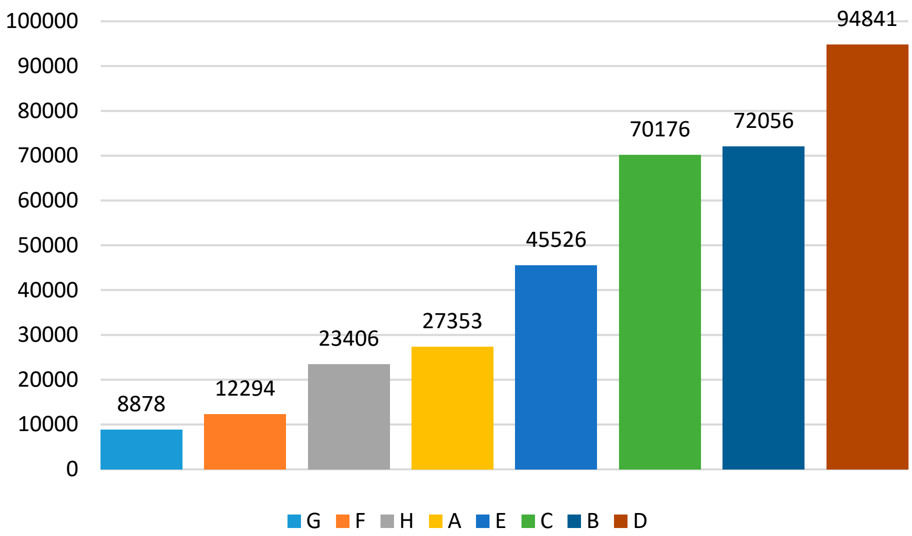

Figure 15. Increasingly ordered values of the ontogenetic matrix determinants calculated for the particular analysed RTEs (A–H).

The median [77,78] of the ontogenetic matrix determinants calculated for the analysed RTEs was 36,439.61. The determinants calculated for RTEs D, B, C, and E were above the median value, and the ontogenetic matrix determinants calculated for RTEs A, H, F, and G were below that value. This explicitly indicated that the level of the positive influence exerted by the implemented IT systems on the organisational efficiency of operational activities undertaken by the analysed enterprises was not the same.

The result achieved by RTE D (the highest level of the matrix determinant) was determined by:

- The highest increase in covered kilometres (which resulted in the broadest scope of the potential of positive influence exerted by the telematics systems in the field of mileage optimisation).
- The highest mileage covered by teams of drivers (two drivers in a team, which resulted in the largest scope of optimisation resulting from the systems implemented in the field of drivers' working time record and settlement or the possibility to form teams).
- A high increase in the number of days when the vehicles are roadworthy (resulting from the use of relevant systems applied to manage maintenance breaks and obligatory inspections; consequently, the possibility to accept more orders/to cover more kilometres was achieved).

The result achieved by RTE G (the lowest level of the matrix determinant) was determined by:

- The lowest mileage covered by teams of drivers (two drivers in a team, which resulted in the narrowest scope of optimisation resulting from the systems implemented in the field of drivers' working time record and settlement or the possibility to form teams).
- A very low level of using drivers' working time (which resulted in a narrow scope of system optimisation in the field of drivers' working time record and settlement, resulting in a decreased number of transport orders and covered kilometres).
- A low increase in the covered kilometres (which resulted in a low scope of the potential of positive influence exerted by the telematics systems implemented in the field of mileage optimisation).

5. Conclusions and Recapitulation

The theoretical considerations and the results of the empirical research presented above allowed the authors to positively verify all assumed research hypotheses.

According to the research findings, the originally developed matrix of rates indicating the organisational efficiency of operational activities, which were determined by the implementation of IT systems in RTEs, met the criteria defining the universal nature of the evaluation and also made it possible to provide a holistic assessment of the analysed RTEs.

The authors are aware of the fact that the operational efficiency of RTEs is affected by a number of factors (including those of an external nature that are independent of the RTEs themselves) [16,17]. However, during research, it was proved that understanding operational efficiency as a combination of managerial efficiency and technical efficiency (including the application of IT technologies to support the management of RTEs) and the purposeful selection of the most universal rates (in the opinion of managerial staff)—which comprise nine elements of the matrix—can adequately document the relationships between the selected components of the matrix, the integrated level of implementation of managerial telematics systems, and the increase of effectiveness in RTEs. In each analysed RTE, the matrix rate indicating organisational efficiency was found to significantly increase after the implementation of integrated IT systems. This proved the hypothesis that there is a correlation between those two elements.

Furthermore, the original method developed to assess the level and the scope of influence exerted by the implemented IT systems on the organisational efficiency of the operational activities undertaken by RTEs (a set of values of the ontogenetic matrix determinants), along with the analytical and algorithmic schemes of the procedures presented in the paper, is flexible enough to be applied to the requirements of comparative analysis in all types of RTEs.

The results of the research explicitly confirm the fact that the implementation of IT systems (especially when considered at the level of IITS, in a holistic way) can improve managerial efficiency in the field of operational activities undertaken by RTEs, and the fact that it can considerably and positively affect the results of operational activities, apart from the limits related to some restraining mechanisms. However, constant software updating—along with the regular replacement of hardware, permanent training provided to the staff working with the systems, and following customer demand and the needs of the evolving market—should also be remembered.

As far as the theoretical aspects are concerned, the authors believe that the results of their research present potential for further theoretical considerations regarding the influence exerted by IT/IITS on the organisational efficiency of RTEs. There is also some potential for theoretical considerations regarding relationships observed between the three variables of the selection of the matrix rates for the evaluation of the implementation results, the integrated level of implementing IT systems, and the accuracy and credibility of the evaluation provided in this way. From a practical point of view, the authors believe that the matrix presented in the paper has considerable potential to be broadly applied as a universal tool to examine and to compare the efficiency of integrated telematics systems in the operational activities undertaken by RTEs. In this way, the discussed matrix fills in a pragmatic gap in this field.

Considering the above-mentioned statements and the results of the previous available research (based on partial fields and selected systemic aspects), the authors believe that the main result of the research was the confirmed existence of a direct correlation between the implementation of integrated telematics systems and an increase in the organisational efficiency of RTEs. The authors believe that this paper also provides managerial staff with an innovative tool to measure the results of IT implementation in a more precise way based on comparable and generally available criteria (with a possibility of comparing particular RTEs). It can undoubtedly bring highly positive results for the process of managerial decision-making related to the purchase and implementation of integrated telematics systems for RTEs, as for the evaluation of managerial efficiency (through managerial decisions). The research of this paper will be continued because it is necessary to verify the matrix in a larger population, to verify a different configuration of the matrix elements, and to develop an application for algebraic operations. Further research will be also necessary to more precisely prove the scale of the influence exerted by IT systems, assuming interactions with other factors in determining efficiency of

RTEs (and how to measure it) and also assuming no interactions with other factors (with all conditions being considered equal).

The authors also believe that the more common and frequent (e.g., quarterly) calculation of matrix values can provide information from a dynamic perspective that should become a significant supporting element in the evaluation of managerial decision results. The fact that numerous matrix elements (rates) are treated as information of commercial sensitivity and the fact that managerial staff members may be unwilling to share data referring to the operational fields of their companies, even though such data are indispensable for calculation and comparison, come as serious limitations to the matrix discussed in the paper.

Considering direct conclusions drawn from the presented research, it is also possible to draw much more general (holistic) conclusions. The use of telematics systems in RTEs provides the opportunity to enrich management in the fields of economy, fuel/energy consumption, human resource productivity, the enlargement of vehicle/truck exploitation periods, and corporate environmental and social responsibility. Moreover, the results of the research may encourage RTEs to improve their technological potential (investment into telematics systems and support for managerial decisions), which should be translated into higher levels of technical/technological competence, higher levels of efficient management, and, eventually, increases in organisational efficiency/effectiveness. In the time of dynamic changes in the market, high uncertainty, the stochasticity of social and economic phenomena (e.g., the COVID-19 pandemic), stronger competitiveness in transport, low freight margins, possible changes in the role and significance of transport in logistic supply chains (in the oncoming post-COVID era), imperatively green and pro-ecological transport, and many other unpredictable factors, the value of winning of some market advantage by RTEs in the form of the organisational efficiency generated by new IT and telematics technologies cannot be underestimated.

Author Contributions: Data curation, M.J.K. and R.K.M.; formal analysis, M.J.K. and R.K.M.; methodology, R.K.M., A.K. and A.B.; project administration, M.J.K.; resources, R.K.M. and M.J.K.; writing—original draft, R.K.M. and M.J.K.; writing—review and editing, A.B. and A.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

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

Nomenclature

A_{gt}	the rate of using roadworthy vehicles
A_t	the rate of technical readiness
B	the rate of using the mileage of the vehicle fleet
$det\ (A)$	matrix A
K_{jz}	the number of kilometres covered by a team of drivers
L_{kmz}	number of kilometres per one transport order
L_{zs}	the number of daily transport orders per a forwarder
$RTEs$	road transport enterprises
T_{jk}	the driver's working time
T_{pz}	the average lead time
T_{zr}	the time required for loading and unloading a vehicle

References

1. Verdonck, L.; Caris, A.; Ramaekers, K.; Janssens, G. Collaborative Logistics from the Perspective of Road Transportation Companies. *Transp. Rev.* **2013**, *33*, 700–719. [CrossRef]
2. Radović, D.; Stević, Ž.; Pamučar, D.; Zavadskas, E.K.; Badi, I.; Antuchevičiene, J.; Turskis, Z. Measuring Performance in Transportation Companies in Developing Countries: A Novel Rough ARAS Model. *Symmetry* **2018**, *10*, 434. [CrossRef]
3. Hernandez, A.; Bernardo, M.; Cruz, C. Relating open innovation, innovation and management systems integration. *Ind. Manag. Data Syst.* **2016**, *116*, 1540–1556. [CrossRef]

4. Chatterjee, K. Modelling the impacts of transport telematics: Current limitations and future developments. *Transp. Rev.* **1999**, *19*, 57–80. [CrossRef]
5. Rosaldo, J.F.; Liu, R.R. An Agent-Based Approach to Assess Drivers' Interaction with Pre-Trip Information Systems. *J. Intellig. Transp. Syst.* **2005**, *9*, 1–10. [CrossRef]
6. Sussman, J.S. *Perspectives on Intelligent Transportation Systems (ITS)*; Springer: Boston, MA, USA, 2005; ISBN 978-0-387-23260-7.
7. Crainic, T.G.; Gendreau, M.; Potvin, J.Y. Intelligent freight-transportation systems: Assessment and the contribution of operations research. *Transp. Res. Part C Emerg. Technol.* **2009**, *17*, 541–557. [CrossRef]
8. Schlote, A.; Faizrahnemoon, M.; Radusch, I.; Crisostomi, E.; Häusler, F.; Shorten, R. A framework for real-time emissions trading in large-scale vehicle fleets. *IET Intell. Transp. Syst.* **2015**, *9*, 275–284. [CrossRef]
9. Joh, C.-H.; Lee, B.; Bin, M.; Arentze, T.; Timmermans, H. Exploring the use of travel information–identifying contextual market segmentation in Seoul, Korea. *J. Transp. Geogr.* **2011**, *19*, 1245–1251. [CrossRef]
10. Giannopoulos, G.A.; McDonald, M. Developments in transport telematics applications in Japan: Traffic management, freight and public transport. *Transp. Rev.* **1997**, *17*, 37–59. [CrossRef]
11. Xu, Y. Development of Transport Telematics in Europe. *GeoInformatica* **2000**, *4*, 179–200. [CrossRef]
12. Janecki, R.; Krawiec, S.; Sierpiński, G. Telematics and the transportation system's value. *IFAC Proc. Vol.* **2010**, *43*, 43–49. [CrossRef]
13. Taniguchi, E.; Yamada, T. Reliable Vehicle Routing and Scheduling with Time Windows Towards City Logistics. In *The Network Reliability of Transport*; Bell, M.G.H., Iida, Y., Eds.; Emerald Group Publishing Limited: Pergamon, Turkey, 2003; pp. 301–322. [CrossRef]
14. Spiekerman, K.; Neubauer, J. *European Accessibility and Peripherality: Concepts, Models and Indicators*; Nordregio Working Paper: Stockholm, Sweden, 2002; pp. 9–11. ISSN 1403-2511. Available online: https://www.diva-portal.org/smash/get/diva2:700463/FULLTEXT01.pdf (accessed on 28 July 2020).
15. Ye, N.; Wang, Z.; Zhang, Y.; Wang, R. A method of vehicle route prediction based on social network analysis. *J. Sens.* **2015**, *15*, 210298. [CrossRef]
16. Ning, Y.; Zhong-Qin, W.; Ru-Chuan, W.; Abdullah, A.H. Design of accurate vehicle location system using RFID. *Elektron. Elektrotechnika* **2013**, *19*, 105–110. [CrossRef]
17. Bäumler, I.; Kotzab, H. Intelligent Transport Systems for Road Freight Transport—An Overview. In *Dynamics in Logistics. Lecture Notes in Logistics*; Freitag, M., Kotzab, H., Pannek, J., Eds.; Springer: Berlin/Heidelberg, Germany, 2017. [CrossRef]
18. Coronado Mondragon, A.E.; Lalwani, C.S.; Coronado Mondragon, E.S.; Coronado Mondragon, C.E. Facilitating multimodal logistics and enabling information systems connectivity through wireless vehicular networks. *Eur. Transp. Res. Rev.* **2009**, *122*, 229–240. [CrossRef]
19. Quinet, E.; Vickerman, R. *Principles of Transport Economics*; Edward Elgar Publishing Ltd.: Cheltenham, UK, 2008; pp. 350–353, ISBN 9781840648652.
20. Giannopoulos, G.A. Towards a European ITS for freight transport and logistics: Results of current EU funded research and prospects for the future. *Eur. Transp. Res. Rev.* **2009**, *1*, 147–161. [CrossRef]
21. Kapsalis, V.; Fidas, C.; Hadellis, L.; Karavasilis, C.; Galetakis, M.; Katsenos, C. A Networking Platform for Real-Time Monitoring and Rule-Based Control of Transport Fleets and Transferred Goods. In Proceedings of the 13th International IEEE Conference on Intelligent Transportation Systems—(ITSC 2010), Funchal, Portugal, 19–22 September 2010; pp. 295–300. [CrossRef]
22. Kortüm, W.; Goodall, R.M.; Hedrick, J.K. Mechatronics in ground transportation-current trends and future possibilities. *Annu. Rev. Control* **1998**, *22*, 133–144. [CrossRef]
23. Gainnopouls, G.A. The application of information and communication technologies in transport. *Eur. J. Oper. Res.* **2004**, *152*, 302–320. [CrossRef]
24. Fouchal, H.; Bourdy, E.; Wilhelm, G.; Ayaida, M. A framework for validation of cooperative intelligent transport systems. In Proceedings of the 2016 IEEE Global Communications Conference (GLOBECOM), Washington, DC, USA, 4–8 December 2016; pp. 1–6. [CrossRef]
25. Fouchal, H.; Wilhelm, G.; Bourdy, E.; Wilhelm, G.; Ayaida, M. A testing framework for intelligent transport systems. In Proceedings of the 2016 IEEE Symposium on Computers and Communication (ISCC), Messina, Italy, 27–30 June 2016; pp. 180–184. [CrossRef]
26. Kolosz, B.; Grant-Muller, S. Sustainability assessment approaches for intelligent transport systems: The state of the art. *IET Intell. Transp. Syst.* **2016**, *10*, 287–297. [CrossRef]

27. Domingues, P.; Sampaio, P.; Arezes, P. Integrated management systems assessment: A maturity model proposal. *J. Clean. Prod.* **2016**, *124*, 164–174. [CrossRef]
28. Trierweiller, A.; Bornia, A.; Gisi, M.; Spenassato, D.; Severo-Peixe, B.; Rotta, M. An exploratory survey on the topic integrated management systems. *Braz. J. Oper. Prod. Manag.* **2016**, *13*, 184–193. [CrossRef]
29. Abad, J.; Dalmau, I.; Vilajosana, J. Taxonomic proposal for integration levels of management systems based on empirical evidence and derived corporate benefits. *J. Clean. Prod.* **2014**, *78*, 164–173. [CrossRef]
30. Rincon-Garcia, N.; Waterson, B.; Cherrett, T.J.; Salazar-Arrietac, F. A metaheuristic for the time-dependent vehicle routing problem considering driving hours regulations–Anapplication in city Logistics. *Transp. Res. Part A* **2020**, *137*, 429–446. [CrossRef]
31. Carlan, V.; Sys, C.; Vanelslander, T. Innovation in Road Freight Transport: Quantifying the Environmental Performance of Operational Cost-Reducing Practices. *Sustainability* **2019**, *11*, 2212. [CrossRef]
32. Gregson, N. Logistics at Work: Trucks, Containers and the Friction of Circulation in the UK. *Mobilities* **2017**, *12*, 343–364. [CrossRef]
33. Huang, S.T.; Bulut, E.; Duru, O. Service quality evaluation of international freight forwarders: An empirical research in East Asia. *J. Shipp. Trade* **2019**, *4*, 14. [CrossRef]
34. Baldini, G.; Sportiello, L.; Chiaramello, M.; Mahieu, V. Regulated applications for the road transportation infrastructure: The case study of the smart tachograph in the European Union. *Int. J. Crit. Infrast. Prot.* **2018**, *21*, 3–21. [CrossRef]
35. Borio, D.; Cano, E.; Baldini, G. Speed Consistency in the Smart Tachograph. *Sensors* **2018**, *18*, 1583. [CrossRef]
36. Steers, R.N. Problems in the measurement of organizational effectiveness. *Adm. Sci.* **1975**, *20*, 546–548. [CrossRef]
37. Farrell, M.J. The Measurement of Productive Efficiency. *J. R. Stat. Soc. Ser. A* **1957**, *120*, 253–290. [CrossRef]
38. Corkrey, R.; Parkinson, L.A. Comparison of four computer-based telephone interviewing methods: Getting answers to sensitive questions. *Behav. Res. Methods Instrum. Comput.* **2002**, *34*, 354–363. [CrossRef]
39. Bush, S.S.; Prather, L. Do electronic devices in face-to-face interviews change survey behavior? Evidence from a developing country. *Res. Politics* **2019**, *6*, 1–7. [CrossRef]
40. Vandenplas, C.; Beullens, K.; Loosveldt, G. Linking interview speed and interviewer effects on target variables in face-to-face surveys. *Surv. Res. Methods* **2019**, *13*, 249–265. [CrossRef]
41. Quinn, R.E.; Rohrbaugh, J. A Spatial Model of Effectiveness Criteria: Towards a Competing Values Approach to Organizational Analysis. *Manag. Sci.* **1983**, *29*, 273–393. [CrossRef]
42. Cameron, K.S. Effectiveness as Paradox: Consensus and Conflict in Conceptions of Organizational Effectiveness. *Manag. Sci.* **1986**, *32*, 513–644. [CrossRef]
43. McShane, S.L.; Von Glinow, M.A. *Organizational Behaviour*; Irwin/McGraw-Hill: Boston, MA, USA, 2000; ISBN1 1259562794, ISBN2 9781259562792.
44. Aktaş, E.; Çiçek, I.; Kıyak, M. The Effect of Organizational Culture on Organizational Efficiency: The Moderating Role of Organizational Environment and CEO Values. *Procedia-Soc. Behav. Sci.* **2011**, *24*, 1560–1573. [CrossRef]
45. Cameron, K.; Organizational Effectiveness. Wiley Encyclopedia of Management. 2015. Available online: https://doi.org/10.1002/9781118785317.weom110202 (accessed on 28 July 2020).
46. Venkataiah, P. Models of organizational effectiveness. *Osman. J. Manag.* **2006**, *2*, 1–7. Available online: http://ou-mba.ac.in/i/3.pdf (accessed on 28 July 2020).
47. Cameron, S.; Whetten, K.; David, A. Organizational effectiveness: A comparison of multiple Models. *J. Policy Anal. Manag.* **1983**, *3*, 477–478. [CrossRef]
48. Ostroff, C.; Schmitt, N. Configurations of organizational effectiveness and efficiency. *Acad. Manag. J.* **1993**, *36*, 1345–1361. [CrossRef]
49. Russell, R. Measures of technical efficiency. *J. Econ. Theory* **1985**, *35*, 109–126. [CrossRef]
50. Nyulásziová, M.; Palová, D. Implementing a decision support system in the transport process management of a small Slovak transport company. *J. Entrep. Manag. Innov.* **2020**, *16*, 75–105. [CrossRef]
51. Krasnyanskiy, M.; Penshin, N. Quality criteria when assessing competitiveness in road transport services. *Transp. Probl.* **2016**, *11*, 15–20. [CrossRef]
52. Grantner, J.; Bazuin, B.; Al-Shawawreh, J.; Castanier, M.P.; Hussain, S. Condition based maintenance for light trucks. In Proceedings of the 2010 IEEE International Conference on Systems, Man and Cybernetics, Istanbul, Turkey, 10–13 October 2010; pp. 336–342. [CrossRef]

53. Kozhukhovskaya, L.; Baskov, V.; Ignatov, A. Modular Management of Indicators of Efficiency and Safety of Transportation Processes. *Transp. Res. Procedia* **2017**, *20*, 361–366. [CrossRef]
54. Özen, M.; Fayyaz, M.; Tüydeş Yaman, H. Factors Affecting the Capacity Utilization of Road Freight Transport in Turkey. *Tek. Dergi* **2020**, *31*, 9813–9832. [CrossRef]
55. Kovács, G.Y. Development of performance evaluation software for road freight transport activity. *Pol. J. Manag. Stud.* **2017**, *15*, 121–134. [CrossRef]
56. Čejka, J.; Telecký, M.; Kolář, J. Appropriate Strategies of Transport Companies for More Efficient Management with the Aim of their Further Assessment Using the Operations Research Methods. *Naše More* **2016**, *63*, 98–101. [CrossRef]
57. Dubrovsky, V.; Yaroshevich, N.; Kuzmin, E. Transactional approach in assessment of operational performance of companies in transport infrastructure. *J. Ind. Eng. Manag.* **2016**, *9*, 389–412. [CrossRef]
58. Nakano, H. A Study on the Features of the Evolution Processes and Business Models of Global Enterprises in the Transport Sector. *Transp. Res. Procedia* **2017**, *25*, 3769–3788. [CrossRef]
59. Durišová, M.; Tokarcíková, E.; Virlanuta, F.O.; Chodasová, Z. The Corporate Performance Measurement and Its Importance for the Pricing in a Transport Enterprise. *Sustainability* **2019**, *11*, 6164. [CrossRef]
60. Tingting, Y.; Xuefeng, G.; Yuehui, Q.; Weiran, X.; Huayi, W. Efficiency Evaluation of Urban Road Transport and Land Use in Hunan Province of China Based on Hybrid Data Envelopment Analysis (DEA) Models. *Sustainability* **2019**, *11*, 3826. [CrossRef]
61. Kos, S.; Vukić, L.; Brčić, D. Comparison of External Costs in Multimodal Container Transport Chain. *Promet-Traffic Transp.* **2017**, *29*, 243–252. [CrossRef]
62. Guo, R.Y.; Szeto, W.Y.; Long, J. Trial-and-error operation schemes for bimodal transport systems, Transportation Research Part B. *Methodological* **2020**, *131*, 106–123. [CrossRef]
63. Bokovets, V.V.; Zamkova, N.L.; Makhnachova, N.M. Assessment of the Effectiveness of Enterprise Management Components in Modern Conditions. *Sci. Bull. Polissia* **2017**, *4*, 27–32. [CrossRef]
64. Kalinichenko, A.; Havrysh, V. Environmentally friendly fuel usage: Economic margin of feasibility. *Ecol. Chem. Eng. S* **2019**, *26*, 241–254. [CrossRef]
65. Malekian, R.; Kavishe, A.; Maharaj, B.T.; Gupta, P.; Singh, G.; Waschefort, H. Smart vehicle navigation system using hidden markov model and RFID technology. *Wirel. Pers. Commun.* **2016**, *90*, 1717–1742. [CrossRef]
66. Hannan, M.; Habib, S.; Javadi, M.; Samad, S.; Muad, A.; Hussain, A. Inter-vehicle wireless communications technologies, issues and challenges. *Inf. Technol. J.* **2013**, *12*, 558–568. [CrossRef]
67. Muerza, V.; Larrodé, E.; Moreno-Jiménez, J.M. Identification and selection of ICTs for freight transport in product service supply chain diversification. *Ind. Manag. Data Syst.* **2017**, *117*, 1469–1484. [CrossRef]
68. Rémy, G.; Mehar, S.; Sophy, T.; Senouci, S.; Jan, F.; Gourhant, Y. Green fleet management architecture: Application to economic itinerary planning. In Proceedings of the 2012 IEEE Globecom Workshops, Anaheim, CA, USA, 3–7 December 2012; pp. 369–373. [CrossRef]
69. McDonald, M.; Keller, H.; Klijnhout, J.; Mauro, V. *Intelligent Transport Systems in Europe: Opportunities for Future Research*; World Scientific Publishing Co. Pte. Ltd.: Singapore, 2006; ISBN 978-981-270-082-7.
70. Transport Drogowy w Polsce w Latach 2014 i 2015. GUS. Available online: http://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/transport/transport-drogowy-w-polsce-w-latach-2014-i-2015,6,4.html (accessed on 4 September 2019).
71. InfoBrokering. Bazy Danych Polskich Firm od InfoBrokering–Jakosc Zbudowana na Doswiadczeniu. Available online: https://www.infobrokering.com.pl/baza-firm-polskich (accessed on 14 October 2019).
72. Jimenez, G.; Novoa, L.; Ramos, L.; Martinez, J.; Alvarino, C. Diagnosis of initial conditions for the implementation of the integrated management system in the companies of the land cargo transportation in the City of Barranquilla (Colombia). In *HCI, CCIS*; Stephanidis, C., Ed.; Springer: Cham, Germany, 2018; Volume 852, pp. 282–289. [CrossRef]
73. Kopishynska, O.; Utkin, Y.; Kalinichenko, A.; Jelonek, D. Efficacy of the cloud computing technology in the management of communication and business processes of the companies. *Pol. J. Manag. Stud.* **2016**, *14*, 104–114. [CrossRef]
74. Stefansson, G.; Lumsden, K. Performance issues of Smart Transportation Management systems. *Int. J. Prod. Perform. Manag.* **2009**, *58*, 55–70. [CrossRef]
75. Hallé, S.; Chaib-draa, B. A collaborative driving system based on multiagent modelling and simulations. *J. Transp. Res. C Emerg. Technol.* **2005**, *13*, 320–345. [CrossRef]

76. Sobamowo, M.G. On the Extension of Sarrus' Rule to n × n (n > 3) Matrices: Development of New Method for the Computation of the Determinant of 4 × 4 Matrix. *Int. J. Eng. Math.* **2016**, 9382739. [CrossRef]
77. Brownrigg, D.R.K. The weighted median filter. *Commun. ACM* **1984**, *27*, 807–818. [CrossRef]
78. Tukey, J.W. *Exploratory Data Analysis*; Pearson: Lebanon, Indiana, USA, 1977; ISBN1 978-0201076165, ISBN2 0201076160.