Article citation info:
ŠKERLIČ S, SOKOLOVSKIJ E, ERČULJ V. Maintenance of heavy trucks: an international study on truck drivers. Eksploatacja i Niezawodnosc – Maintenance and Reliability 2020; 22 (3): 493–500, http://dx.doi.org/10.17531/ein.2020.3.12.

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MAINTENANCE OF HEAVY TRUCKS: AN INTERNATIONAL STUDY ON TRUCK DRIVERS

OBSŁUGA TECHNICZNA SAMOCHODÓW CIĘŻAROWYCH: MIĘDZYNARODOWE BADANIE KIEROWCÓW CIĘŻARÓWEK

Since the implementation of modern approaches in operation maintenance, drivers are expected to be integrated into the entire system of maintenance in order to take over the professional competencies of maintenance workers. For this purpose, an international study was conducted on a sample of 249 truck drivers, with the aim to determine how maintenance in transport companies affects the role of heavy truck drivers in fleet maintenance. Based on the developed SEM model, it was determined that building an efficient maintenance infrastructure in transport companies enables the active participation of truck drivers in the company's maintenance system. Drivers are capable of repairing minor failures, but only if they are proactive, which will affect their preventive behaviour. This can greatly benefit transport companies, as the results show that the vehicles are utilised more efficiently and in a better technical condition. The results therefore represent an important guideline for improving maintenance in transport companies, developing new competencies of truck drivers and upgrading existing knowledge in the development of modern operation maintenance.

Keywords: *maintenance, maintenance strategy, heavy trucks, truck drivers.*

Od czasu wdrożenia nowoczesnych metod obsługi technicznej, kierowcy powinni zostać zintegrowani z całym systemem obsługi technicznej, aby przejąć kompetencje zawodowe pracowników obsługi technicznej. W tym celu przeprowadzono międzynarodowe badanie na próbie 249 kierowców ciężarówek w celu ustalenia, w jaki sposób obsługa techniczna w firmach transportowych wpływa na rolę kierowców ciężarówek w utrzymaniu floty. Na podstawie opracowanego modelu równania strukturalnego (SEM) ustalono, że zbudowanie efektywnej infrastruktury serwisowej w firmach transportowych umożliwia aktywny udział kierowców ciężarówek w systemie obsługi technicznej firmy. Kierowcy są zdolne do naprawy drobnych usterek, ale tylko wtedy, gdy są proaktywni, co wpłynie na ich zachowanie zapobiegawcze. Może to być bardzo korzystne dla firm transportowych, ponieważ wyniki pokazują, że pojazdy są użytkowane bardziej wydajnie i w lepszym stanie technicznym. Wyniki stanowią zatem ważną wskazówkę dotyczącą poprawy obsługi technicznej w firmach transportowych poprzez rozwój nowych kompetencji kierowców ciężarówek i poszerzanie istniejącej wiedzy w zakresie rozwoju nowoczesnej obsługi technicznej.

Słowa kluczowe: *obsługa techniczna, strategia obsługi technicznej, samochody ciężarowe, kierowcy ciężarówek.*

1. Introduction

The introduction of modern maintenance strategies highlights a changed understanding of the organisation of maintenance, which leads to greater collaboration and teamwork in the company-wide maintenance process. An important feature of modern strategies is the introduction of independent machine and device maintenance by the operators, that is, connecting many basic service actions with the manufacturing process. Modern maintenance strategies therefore focus on two aspects of enhancing the competencies of employees: the first is to improve the competence of the staff responsible for operation maintenance. Another aspect is the inclusion of operators in the works for operation maintenance and the transfer of responsibility to them allows for a better utilisation of the knowledge they possess, reinforces their sense of their own value and makes them aware of their participation in the achievement of the enterprise's objectives [24].

However, there is a fundamental difference between the maintenance of machinery in manufacturing and fleet maintenance in companies. While researchers and maintenance engineers in manufacturing companies are thoroughly invested in enhancing the advanced actions of operators in machine maintenance [3], the maintenance of heavy truck drivers remains a neglected and under-researched field. Working in the transport industry has its own unique features, since the average driver in international transport spends five days a week in a truck and averages between 2,500 and 3,000 km [20]. Therefore, the driver interacts with the truck constantly and is the first person who is able to detect any potential technical deficiencies. The driver's response to unforeseen circumstances must therefore be timely and effective, which can significantly reduce potential costs. An unplanned stop at the roadside not only delays delivery but can also cause damage to the cargo [38].

In addition to requiring that the truck driver has the necessary professional competencies, transport companies should consider utilising the potential that drivers can represent in strategic fleet maintenance. Modern maintenance principles expect transport companies to integrate drivers into the entire maintenance system in order to take over parts of the professional competencies of maintenance workers. Transport companies must therefore ensure that drivers are adequately trained in the following aspects of maintenance: reactive action (the driver can remedy minor failure on the truck); preventive action (the driver inspects the truck before and after the trip is completed and notes any detected issues) and predictive-proactive action (the driver participates in the maintenance process and proposes corrective maintenance actions at company level).

But are heavy truck drivers prepared to do all this? Are international road transport companies capable of operating according to modern maintenance principles, much like manufacturing companies already do?

To answer these research questions, a study was conducted on a sample of 249 drivers in international road transport. The aim of the study is to determine how maintenance in transport companies affects the role of drivers in maintenance and the consequent optimal utilisation and roadworthiness of the trucks. To this end, the Structural Equation Model (SEM) was developed, which includes three research phases. The first phase consists in determining how maintenance in transport companies affects the reactive, preventive and predictive-proactive maintenance by truck drivers. The second phase consists in determining how individual driver maintenance affects truck utilisation. The third phase analyses the claim that the truck is in a good technical condition, despite the truck's high level of utilisation.

The results obtained build upon the current field of research into modern maintenance strategies, as they highlight the importance of establishing an efficient maintenance infrastructure in transport companies. This allows drivers to be actively engaged in the company's maintenance system, which ensures that the trucks are in a better technical condition, despite their high utilisation. The results therefore represent an important guideline for improving maintenance in transport companies, developing new competencies of truck drivers and upgrading existing knowledge in the development of modern operation maintenance. The article is structured as follows: the second part provides an overview of the literature in the field of maintenance, and an SEM model that was developed based on gaps in theory and practice. The research methods used are presented, followed by the results obtained on a sample of heavy truck drivers. The article continues with a discussion of the results, which highlights the contribution to maintenance theory and practice in transport companies. The conclusion highlights the limitations of the research and provides suggestions for further research.

2. Literature Review and Development of a Structural Research Model

The development of maintenance approaches allows for the distinction of three periods. The first period is characterised by reactive maintenance without prior planning. Repairs are only made when a failure occurs. According to Dekker [7], such an operational level of maintenance is difficult to manage due to possible unplanned events. If these events occur frequently, they interrupt important planned activities and prevent strategic thinking. This explains to some extent the general problem with maintenance dynamics, which typically overburdens the maintenance department with reactive work instead of proactive activities [16]. Although neglecting maintenance activities can have short-term effects, such as lower costs or more production hours, it can eventually cause problems resulting from more frequent failures, reduced capacity, or less time for continuous improvement [26].

That is why the second maintenance period is focused on preventive maintenance, with a focus on planned and preventive repairs. This enables companies to avoid unexpected component breakdowns based on a preventive maintenance plan [15]. However, Legutko [24] emphasises that the strategy of preventive operation maintenance is not successful when a significant number of failures occur at an early stage of utilisation. This fact and the increasing number of utilised machines/trucks in companies and devices of growing value have changed the attitude to this maintenance mindset.

The third period of maintenance therefore focused on predictive-proactive maintenance aimed at ensuring the smooth operation of machines and devices throughout their period of utilisation. This approach has given rise to various modern maintenance strategies, such as: TPM (total productive maintenance), RCM (reliability centred maintenance, RBI (risk-based inspection), CBM (condition-based monitoring), CMMS (computerised maintenance management software), RAM (Reliability, availability and maintainability program), OTI (Operator's own technical inspections), TSM (Technical systems maintenance), PDSS (Promise decision support system) and Lean principles.

The goal of predictive-proactive maintenance is to avoid as many system breakdowns as possible using historical data, empirical tests and statistical calculations. This puts into direct relation the time (working time and/or life span) with the probability of system breakdown [15]. However, the first condition for introducing modern maintenance strategies is to identify the maintenance function as an important strategic area within the company. Performing strategic operation maintenance within a company involves identifying and eliminating the basic losses that may occur: loss of availability (machine failures, adjustment and tool exchange), losses of performance (idling, reduced operating speed), and quality loss (rejects and modifications, losses due to test batches). Its implementation requires: the preparation of a program ensuring autonomous realisation of the operation maintenance works, planning of the activity for the organisational unit responsible for the operation maintenance works, improvement of the skills of the staff responsible for operation maintenance, and the preparation of a program oriented for optimisation of the work of new machines and devices [24].

The introduction of modern maintenance strategies also highlights a changed understanding of the organisation of maintenance, which leads to greater collaboration and teamwork in the company-wide maintenance process. An important feature of modern strategies is the introduction of independent machine and device maintenance by the operators, that is, connecting many basic service actions with the manufacturing process. This highlights the new role that operators are expected to play in relation to the machine that is not merely associated with production tasks but also with maintenance tasks. Initially, all observations of the functioning of machines and devices are performed by operators during their normal work, such as watching the instrumentation, day-to-day checking of predetermined elements with the use of physical effects such as smell, sounds, vibration, temperature, sight observation, changes of appearance, necessity to apply force etc. Then, after training, the operators perform inspections on their own, take full responsibility for the inspections, maintenance, cleaning, adjustments and small repairs [13, 24].

Therefore, the efficiency of the introduction of modern maintenance strategies largely depends on ensuring adequate resources for their implementation. The main factor that affects the quality of maintenance processes is competent employees. Their knowledge, skills and ability to respond to unexpected situations largely determine the efficiency of the functioning of the technical infrastructure in an enterprise [3]. Modern maintenance strategies therefore focus on two aspects of enhancing the competencies of employees: the first is to improve the competence of the staff responsible for operation maintenance. Another aspect is the engagement of operators in the works for operation maintenance and the transfer of responsibility to them allows for a better utilisation of the knowledge they possess, reinforces their sense of their own value and makes them aware of their participation in the achievement of the enterprise's objectives [24].

However, there is a fundamental difference between the maintenance of machinery in manufacturing and fleet maintenance in companies. While researchers and maintenance engineers in manufacturing companies are thoroughly invested in enhancing the advanced actions of operators in machine maintenance [3], the role of the driver in truck maintenance remains a neglected and under-researched field. Working in the transport industry has its own unique features, since the average driver in international transport spends five days a week in a truck and averages between 2,500 and 3,000 km [20]. Therefore, the driver is the first person who is in the position to detect any potential issues with the truck, even more so than the machine operator. The driver's response to unforeseen circumstances must therefore be timely and effective, which can significantly reduce potential costs. An unplanned stop at the roadside not only delays delivery but can also cause damage to the cargo [38].

That is why the truck driver must be properly trained. The requirements for truck drivers in terms of knowledge and skills in the area of maintenance do not differ in the EU [39] and in the USA [6]. In both cases, the service provided by the driver is defined as the transport and delivery of cargo to a specified location within the prescribed time. The driver is responsible for keeping the vehicle clean and regularly maintained. The driver must also have a vocational high school diploma. The US Department of Labor [6] adds that the drivers must inspect their trucks before and after the trip and record any defects they find. They must immediately report any technical problems to the competent staff.

However, the required knowledge and competencies of drivers may not suffice, if companies in the transport industry fail to utilise the potential that drivers can represent in the efficient maintenance of the fleet. As the driver is identified as the first person able to detect and correct potential defects on the truck, the aim of the study is to determine how maintenance in transport companies affects the role of drivers in truck maintenance.

To this end, the Structural Equation Model (SEM) was developed, which includes three research phases (Fig. 1). In the first phase, it is determined how maintenance in transport companies (MTC) affects truck drivers' ability to perform small repairs (SR), preventive maintenance (PRE) and proactive maintenance (PRO). The second phase continues by determining how individual maintenance by the driver affects truck utilisation (TU), measured in kilometres driven. The third phase concludes the study with an analysis of the claim that the truck is in a good technical condition (TCT), despite the truck's high level of utilisation. This is possible due to the coordinated work by all the persons involved in the company's maintenance process.

The SEM model is based on the following hypotheses:

H1: Maintenance in transport companies affects truck drivers' ability to perform small repairs.

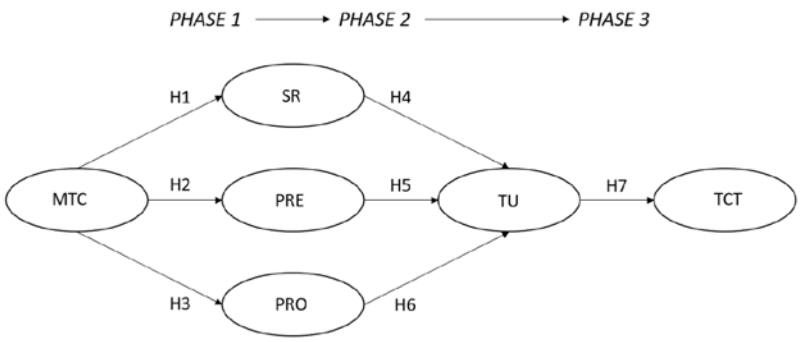


Fig. 1. Structural Equation Model

Much like machine operators, drivers in transport companies must also be trained to perform small repairs [1, 18], such as changing tires, oil, lights, and keeping the truck clean.

H2: Maintenance in transport companies affects the drivers' ability to take preventive action.

Much like machine operators, drivers in transport companies must also be trained to inspect the truck's equipment and supplies [16, 18], such as tires, lights, brakes, oil and water, in the context of preventative maintenance. In the event of mechanical problems, the driver must inform the appropriate personnel. The driver must prepare truck inspection reports and keep records of maintenance work/repairs performed.

H3: Maintenance in transport companies affects the drivers' ability to take proactive action.

Much like machine operators, drivers in transport companies must also be trained to plan maintenance, to participate in the maintenance process, and be encouraged to propose corrective actions at company level [25, 29], in the context of predictive-proactive maintenance.

H4: The ability of the driver to perform small repairs affects the truck's utilisation.

The driver immediately repairs the trucks when a minor failure occurs, instead of adding to the workload of the maintenance department. By doing so, drivers improve the availability and utilisation of the truck and avoid becoming standing by the road unable to continue the transport mission [38].

H5: The driver's ability to take preventive action affects the utilisation of the truck.

If the driver discovers technical issues with the truck before the start of the trip and after the trip, and promptly resolves them or informs the maintenance department in a timely manner, future failures on the road can be avoided. An unplanned stop not only delays delivery but can also cause damage to the cargo. Thus, an ability to detect early symptoms of wear, before they become real problems, has the potential to improve the truck's availability and utilisation [32].

H6: The drivers' ability to take proactive action affects the truck's utilisation

A high degree of availability can be achieved by frequently replacing components, but this approach can be expensive, not only because of frequent visits to the workshop, but also because of the cost of components. Therefore, failure prognostics and thinking about what needs to be improved in truck maintenance represent the highest level of development in maintenance by drivers [38]. Such driver action leads to greater engagement and teamwork in the maintenance process [28].

H7: Higher truck utilisation does not affect the truck's technical condition

The higher the level of utilisation of the vehicle, the greater the chance of failure and component wear. However, due to the effect of maintenance in transport companies on reactive, preventive and predictive-proactive maintenance by truck drivers, the truck remains in a good technical condition.

3. Methods

The study was conducted on a sample of 249 heavy truck drivers employed in the international road freight transport sector. For this purpose, an online questionnaire was prepared and sent via SMS to individual truck drivers at truck terminals in Koper (Slovenia) and Trieste (Italy). These two locations were selected due to the high number of trucks passing through and the proximity of the ports of Trieste (Italy) and Koper (Slovenia). Due to the international nature of the study, the online questionnaire allowed the respondents to answer in Italian, Slovenian, Croatian, Serbian and English. Prior to the official submission of the questionnaire to the drivers, the questionnaire was examined by five heavy truck drivers who were not subsequently included in the study. Of the 731 drivers who were invited to the take part in the study, 249 drivers accepted the invitation and also completed the online questionnaire. 96 truck drivers were from Slovenia, 92 from Serbia, 37 from Croatia, 22 from Italy and 2 from Austria. The response rate was 34%. The final sample of respondents who completed the questionnaire in its entirety included 220 drivers. The study was divided into two parts. The first general part is connected to the demographic information such as the gender, age and education level of heavy truck drivers. The second part of the study focuses on thematic sections related to maintenance in companies, maintenance by drivers, technical characteristics and truck utilisation.

3.1. Measures

Maintenance in transport companies (Cronbach's $\alpha = 0.81$) was measured by three indicators: "The company regularly conducts preemptive truck inspections every weekend", "The company ensures that every technical issue of the vehicle is quickly fixed" and "The company provides me with training about basic vehicle maintenance procedures".

Preventive behaviour of the truck drivers (Cronbach's $\alpha = 0.82$) was measured by two items: "Before I start driving, I always perform a "walk around" check to spot potentially dangerous issues" and "I immediately notify the company in case of any issues spotted during the maintenance of the truck" Cronbach's α equals 0.82.

Proactive behaviour of the truck drivers was a single item measure "I often think about what needs to be improved on truck maintenance".

Inclination to do small truck repairs (Cronbach's $\alpha = 0.85$) was measured by two items: "If necessary, I change the headlight bulb of the truck" and "I regularly clean the cab".

Technical condition of the truck (Cronbach's $\alpha = 0.78$) was measured by two items: "The truck I'm driving is in good condition, based on visual inspection" and "The truck is comfortable to drive".

Truck utilisation was a single-item measure. Respondents answered the question "What is your average number of kilometres driven per week?".

3.2. Procedure

Data analysis followed the two-step approach suggested by Anderson and Gerbing [2], evaluating measurement model via exploratory and confirmatory factor analysis in the first step and building a structural equation model in the second. Robust maximum likelihood method of parameter estimation as proposed by Boomsma & Hoogland [5] for data not following multivariate normal distribution was used for the evaluation of measurement and for the structural model. The error variance of the constructs with a single indicator was set to 0.

If each observable variable loaded statistically significantly onto the factor it was supposed to measure, this was considered a sign of convergent validity [2, 19, 34, 37]. Furthermore, item loadings on the factor were supposed to be higher than 0.5 [21, 34]. The sign of convergent validity was also a good overall fit of the model [34].

Composite reliability and average variance extracted (AVE) were calculated. The first is the reliability of a summated scale and the second the variance in the indicators explained by the common factor. The composite reliability above 0.6 indicates good reliability and AVE above 0.5 good construct validity [14]. Reliability was assessed also by Cronbach's α. The values above 0.70 were considered to indicate adequate reliability as proposed by Nunnally [31].

Discriminant validity was assessed by examining correlations between constructs. As a rule of thumb, correlation between latent variables should not exceed $r = 0.85$, otherwise one can conclude that there is a lack of discriminant validity [23]. Discriminant validity is supported further if the 95% confidence interval for the correlation coefficient between two latent variables does not include 1 [35]. If the AVE by the correlated latent variables is greater than the square of the correlation between the latent variables, then discriminant validity exists [14].

After establishing good measurement validity, a structural equation model was built. Partial disaggregation approach was used due to the rather small sample size in which subsets of items were combined into composites (averages) that were then treated as indicators of the constructs. Error variances of the indicators were calculated as (1-reliability)*variance of the indicator.

The fit of the model was evaluated using the Sattora-Bentler scaled Chi Square, which is suitable for evaluating models with non-normal data [5]. In addition, the Comparative Fit Index (CFI), Incremental fit index (IFI), non-normed fit index (NNFI), the Root Mean Square Error of Approximation (RMSEA), and the Standardised Root Mean Square Residual (SRMR) were used. Values of .95 or and above or 0.90 and above for CFI, NNFI and IFI, and values of 0.08 and below for RMSEA and SRMR indicate a good fit of the model [22]. Modification indices and standardised residuals were used to suggest improvements of the model.

LISREL 9.30 was used for model calibration and hypotheses testing.

4. Results

The final sample included $n = 220$ truck drivers. One woman participated in the study, while other participants were males. The average age (SD) of participants was 40.8 (10.7) years. Approximately one third (37.7 %) had more than high-school education. The average (SD) number of years working as a truck driver was 13.7 (10.1) years. On average (SD), they are employed at the current employer for 5 (5.1) years.

Confirmatory factor analysis showed good overall fit of the measurement model (SB $\chi^2 = 35.02$; df = 31; p = 0.283; SB χ^2/ df = 1.1; RMSEA = 0.059; NFI = 0.97; NNFI = 0.99; CFI = 0.99; IFI = 0.99; SRMR = 0.04; GFI = 0.96). Convergent validity was further supported by significant and substantial (> 0.50) loadings for all items in the model. AVE for all constructs was 0.60 or higher for all constructs, supporting construct validity.

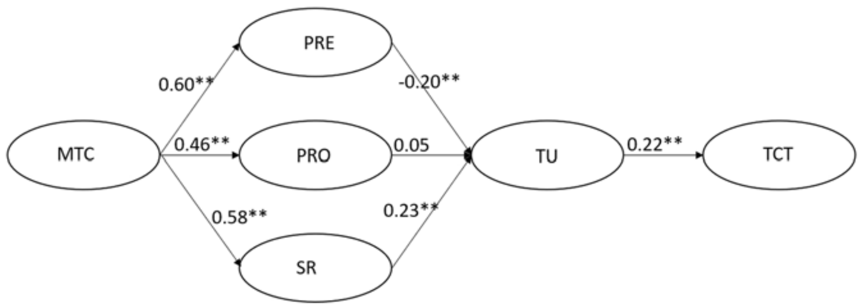
Descriptive statistics for composite variables (averages of the indicators measuring each construct) and correlations are presented in Table 1. None of the correlation coefficients exceeds 0.85 and none of their confidence intervals include 1. None of the squared correlation coefficients exceeds AVE. From the stated, it is concluded that there is good discriminant validity of the used measures.

The hypothesis testing included building proposed structural equation model. The structural equation model with standardised regression coefficients is depicted in Fig. 2. All presupposed paths are statistically significant but the one from proactive behaviour to truck

Table 1. Correlation matrix of composite measures

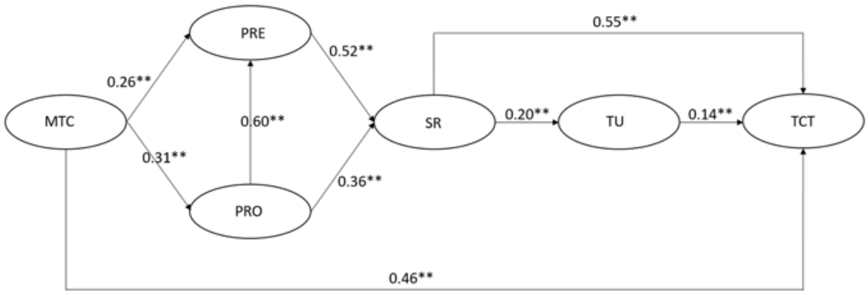
	M	SD	PRE	SR	MTC	TCT	PRO	TU
PRE	4.44	0.71	1					
SR	4.31	0.85	0.65**	1				
MTC	3.87	0.95	0.37**	0.36**	1			
TCT	4.41	0.74	0.45**	0.63**	0.53**	1		
PRO	4	1.01	0.62**	0.65**	0.28**	0.51**	1	
TU	2561.5	690.4	0.05	0.20**	−0.05	0.20**	0.12	1

** p < 0.05; ** p < 0.01; MTC = maintenance in transport companies; PRE = preventive behaviour; PRO = proactive behaviour; SR = small repairs; TCT = technical condition of the truck; TU = truck utilisation*



**p < 0.05; ** p < 0.01*

Fig. 2. Structural equation model (standardised regression coefficients are shown; MTC = maintenance in transport companies; PRE = preventive behaviour; PRO = proactive behaviour; SR = small repairs; TCT = technical condition of the truck; TU = truck utilisation)



**p < 0.05; ** p < 0.01*

Fig. 3. Modified structural equation model (standardised regression coefficients are shown; MTC = maintenance in transport companies; PRE = preventive behaviour; PRO = proactive behaviour; SR = small repairs; TCT = technical condition of the truck; TU = truck utilisation)

utilisation. The fit of the model, however, is very poor (SB χ^2 = 113.5; df = 8; p < 0.001; SB χ^2/ df = 14.2; RMSEA = 0.45; NFI = 0.77; NNFI = 0.58; CFI = 0.78; IFI = 0.78; SRMR = 0.27; GFI = 0.63).

Due to poor fit of the presupposed structural model, the modification of the model was done and the modified model is depicted in Fig. 3. The model exhibits good overall fit (SB χ^2 = 8.6; df = 6; p < 0.200; SB χ2/ df = 1.4; RMSEA = 0.083; NFI = 0.98; NNFI = 0.99; CFI = 0.99; IFI = 0.99; SRMR = 0.04; GFI = 0.98). It presupposes full mediation of the proactive and preventive behaviour of the driver between the maintenance in transport companies and small repairs done by the driver. Partial mediation through truck utilisation is present between small repairs done by the driver and the technical condition of the truck. Maintenance in transport companies influences the technical condition of the truck directly, as well as through the driver's preventive and proactive behaviour and truck utilisation.

5. Discussion

The results of the study indicate that truck drivers are able to participate in the maintenance process in transport companies, as they are trained to perform minor maintenance operations in the same way as machine operators [1, 18]. Drivers can also be steered toward preventive thinking, as they immediately report any defects on the truck and always perform a 'walk around' check to spot potential issues. The same goes for proactive action, as drivers often think about what needs to be improved in truck maintenance. This is also in line with current operational maintenance guidelines, where part of the maintenance personnel tasks is transferred to the direct users of machines or devices [24]. Based on this, the first research question can be answered, since the basic results of the study indicate that truck drivers are willing and able to actively participate in the maintenance system of transport companies. They are able to perform minor maintenance work and act both preventively and proactively. The results therefore build upon the set of professional competencies as indicated in the recommendations by the Ministries of labour and employment in the EU [39] and in the US [6] and highlight the new role that truck drivers must play in operation maintenance. This role consists in an active involvement in the whole process of fleet maintenance in transport companies. The results also add to the official maintenance standards in the transport industry, developed by the British DVSA - Driver and Vehicle Standards Agency [12], where the tasks of the driver are limited to daily routine truck inspection and prompt reporting and recording of all technical defects [27].

However, an important aspect of building an effective maintenance infrastructure consists primarily in determining whether transport companies are capable of operating according to modern operating maintenance principles, as is common in the manufacturing industry. This aspect was addressed by the second research question. The basic results of the survey, i.e. the median value, showed that, on average, the companies in the sample have a well-organised system of fleet maintenance. However, in order to determine how maintenance in transport companies affects the role of the drivers in the maintenance and consequent utilisation and good technical condition of trucks, an SEM model was developed and divided into the three research phases, as shown in Fig. 1. The results of the first research phase showed that the effective functioning of operation maintenance in transport companies affects the ability of truck drivers to operate within the framework of preventive and proactive maintenance. The results are also in line with modern preventive maintenance guidelines in the manufacturing industry, according to which machine operators can only act preventively and proactively, if the companies provide an adequate maintenance infrastructure: from enhancing the maintenance competencies of users of machinery or transport vehicles [3] to the introduction of modern operation maintenance processes [25].

Transport companies that are systematically focused on fleet maintenance enable drivers to participate in the maintenance process and encourage them to propose corrective actions. As indicated by the results of the final part of the first research phase, truck drivers who are proactive also tend to act preventively. This allows them to be able to repair minor failures, resulting in higher truck utilisation and more kilometres driven. This is also the final result of the second research phase, in which the goal was to determine how individual maintenance by the driver affects truck utilisation, as measured in kilometres driven. The results of the second research phase point out that, by doing so, drivers improve the availability and utilisation of the truck and avoid becoming standing by the road unable to continue the transport mission [38]. In addition, the ability to detect early symptoms of wear, before they become real problems, has the potential to improve the truck's availability and utilisation, and the drivers' ability to take timely action [32].

The third research phase of the SEM model rounded off the entire research field of operation maintenance, both in comparison with the manufacturing activity, as well as by setting future guidelines for operation maintenance in the transport industry. The third phase concludes the study with an analysis of the claim that the truck is in a good technical condition, despite the truck's high level of utilisation. The results showed that this is only possible with the coordinated action of all the persons involved in the company's maintenance process. The first condition is that companies must have an effective operation maintenance infrastructure in place, which enables them to conduct a preventative inspection of the truck every weekend, to quickly eliminate any technical defects on the vehicle and to provide truck drivers with training on the basic procedures of vehicle maintenance. As a consequence, the drivers will be more proactive, which will affect their preventive action. This will enable them to repair minor failures, which will result in better utilisation of the truck. Despite being utilised more, the trucks will remain in a good technical and visual condition, which is the most important finding of the research. The final finding therefore highlights the importance of establishing an adequate maintenance infrastructure in the company and, above all, how it affects the participants in the maintenance process.

5.1. Contribution to Theory and Practice

The results can be generalised to the entire transport industry, as the study was conducted on a sufficiently large number of truck drivers. Several studies have focused on the work of truck drivers in the transport industry, but all were limited to researching the labour law aspect (regulations regarding driving time, rest time, hours of service violations, etc.), driver health issues (fatigue, general health, etc.), and driver behaviour in traffic (research via DBQ - Driver Behaviour Questionnaire). The study thus represents an original scientific novelty, as it is the first study that examines the position of maintenance in the transport industry and in particular how maintenance in transport companies affects the role of drivers in maintenance and the consequent optimal utilisation and roadworthiness of the trucks. The research gap is not only noticeable in scientific publications but also in EU laws, since Directive 2003/59/EC [11], which defines the procedures for obtaining a basic professional qualification, Directive 2014/45/EU (on periodic roadworthiness tests for motor vehicles and their trailers) [8], Directive 2014/46/EU (on the registration documents for vehicles) [9], and Directive 2014/47/EU (on the technical roadside inspection of roadworthiness of commercial vehicles) [10], do not specifically define the role of drivers in fleet maintenance. Unlike in the transport industry, the field of maintenance in the manufacturing industry is undergoing continuous development in research, since the first studies on modern approaches to maintenance date back to the 1970s [24].

The innovativeness of the results therefore affects the following theoretical, practical and legislative areas of maintenance in the transport industry:

- Truck maintenance: It was determined that drivers play an important role in fleet maintenance. Drivers are capable of repairing minor failures, but only if they are proactive, which will affect their preventive behaviour. This can greatly benefit transport companies, as the results show that the vehicles are utilised more efficiently and in a better technical condition. The main novelty consists in the fact that truck utilisation is affected not only by the economical driving of truck drivers, as pointed out by Lowe & Pidgeon [27] and Muha & Sever [30], but also by their active involvement in the company's maintenance process.
- Development of truck drivers' competencies: The requirements for truck drivers regarding professional training in the EU are limited to the basic qualification - code 95. New legislation in the road freight transport sector requires that all new drivers must obtain a basic qualification - code 95, which they obtain on the basis of a theoretical and practical exam before a state commission [11, 34]. The results highlight the importance of training truck drivers in the field of vehicle fleet maintenance, as transport companies that operate in this way also have vehicles that are in better technical condition. Knowledge of fleet maintenance is not specifically covered by code 95 training, thus the study highlights further directions in the training of truck drivers and expands the required competencies both in the practical and in the legislative field.
- Maintenance improvements in transport companies: It was determined that companies will only be able to take advantage of the driver's maintenance potential, if they have an effective operation maintenance infrastructure in place, which enables them to conduct a preventative inspection of the truck every weekend, to quickly eliminate any technical defects on the vehicle and to provide truck drivers with training on the basic procedures of vehicle maintenance. Since this area is unresearched, the results represent an important guideline for establishing the strategic role of maintenance in transport companies and the efficient organisation of maintenance at all levels in the company. This is especially important since the field of operation maintenance development in the transport industry is lagging behind the manufacturing sector, where the guidelines for the operation of the maintenance function are clearly defined within Industry 4.0 [33].
- The results build upon existing knowledge in the field of modern operation maintenance development, as they show how the maintenance function is tied into a series of interconnected maintenance actions in transport companies. The responsibility for the development of maintenance infrastructure and efficient operation maintenance, which ultimately leads to a better condition of vehicles, therefore depends on the management of the company responsible for establishing an adequate maintenance infrastructure. The results are therefore consistent with the study by Bokrantz et al. [4], where they highlight scenarios for future modern maintenance management by 2030. The study emphasises that corporate leadership should be aware of the fact that failure to develop an adequate level of competence is linked to an inefficient maintenance process, which in turn increases the sensitivity to disturbances, decreases the responsiveness to failures, and at the same time reduces the competitiveness of the company. Therefore, education and training of employees is an absolute necessity, as well as developing new ways of managing competencies in the company maintenance process. While Bokrantz et al. [4] highlighted guidelines for future operation maintenance by 2030, some of their recommendations have been explicitly confirmed by the results of the presented study.
- The study synthesises and analyses the literature in the field of maintenance development through different maintenance periods, which is an important framework for future empirical studies in the transport industry, as well as in the field of operation maintenance in general.

Although the survey included truck drivers from Slovenia, Italy, Serbia and Croatia, the results are representative for the whole EU area and not just for the Central European region or for each individual country. This assertion can be justified by the fact that all truck drivers driving in the EU operate within the framework of the uniform law provisions related to working time, obligatory rest periods for mobile workers and recording equipment used in road transport [30]. Furthermore, the transport companies where truck drivers work must ensure that their fleet is in compliance with uniform EU legislation [8-10]. As truck drivers operate according to uniform rules, it is possible to draw global-scale conclusions from the study and highlight suggestions for improvements in operational maintenance in the transport industry, which are the following:

- Improving the level of operational maintenance in transport companies,
- Training of drivers for basic qualification (code 95), which is a prerequisite for drivers to operate within the EU, should include training in fleet technical maintenance,
- EU legislation should state that truck drivers must also be responsible for the roadworthiness of trucks.

5.2. Limitations and Recommendations for Future Studies

This is the first study that deals with the field of operation maintenance in the transport sector. Therefore, it was not possible to make a substantial comparison of the results with previous studies. In this regard, the limitations of the study also dictate recommendations for future studies, since it would be advisable to repeat a similar study in the future and compare the evolution of the maintenance function in the transport industry. As regulations governing the work of drivers differ around the world, which can affect their ability to maintain the fleet, it would be advisable to conduct a related study in the US, in Australia, in Canada and in other countries.

In the future, the field of operation maintenance should be regulated in more detail within the EU legislation (via system instructions and procedures), since there are no specific guidelines as to who is in charge of managing maintenance procedures in a transport company and how these procedures should be managed. EU legislation [8-10] states that keeping the truck in a roadworthy condition is solely the responsibility of the transport company and this is as far as this area of maintenance is addressed. Systematic truck maintenance is especially important from a safety point of view, since a road accident that results in a technically defective truck often has more serious consequences than if caused by other vehicles. Therefore, it is essential that other subjects in transport companies are included in the legislation that regulates responsibilities in operation maintenance. The study results show that drivers can significantly contribute to the roadworthiness of the fleet. Unlike continental Europe, in the UK, the DVSA [12] defines, through clear procedures, the driver's responsibility for operation maintenance. In these procedures, drivers are required to formally record all defects on the truck, any repairs made and the signature of the person who carried out the repair. Drivers are also required to indicate how much time they spend on daily 'walk around' checks. The drivers' tachographs must clearly show the time spent on the checks performed before driving on the road. This is not clearly defined and regulated in the continental EU.

The following recommendation for further research is related to the future development of trucks and driver-assistance systems that change the way driving is done, as well as truck maintenance procedures. The competencies required from drivers will change accordingly, and both research and modern recommendations for operation maintenance from a technical, organisational and human resources development point of view will have to follow.

6. Conclusions

While there have been many studies on the subject of the transport of goods in international transport, this is the first study to examine how maintenance in transport companies affects the role of drivers in fleet maintenance. The results obtained build upon the current field of research into modern maintenance strategies, as they highlight the importance of establishing an efficient maintenance infrastructure in transport companies. This allows drivers to be actively engaged in the company's maintenance system, which ensures that the trucks are in a better technical condition, despite their high utilisation. The results therefore represent an important guideline for improving maintenance in transport companies, developing new competencies of truck drivers and upgrading existing knowledge in the development of modern operation maintenance.

Although this is the first study conducted in the field of operation maintenance in the transport industry, the research has its limitations, tied to the inability to compare the results with previous studies. This limitation also dictates future recommendations, since it would be advisable to repeat a similar study in the future and compare the evolution of the maintenance function in the transport industry.

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