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DO TELEMATICS TECHNOLOGIES HELP TO MANAGE ROAD TRANSPORT ENTERPRISES? EVIDENCE FROM SME IN POLAND

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Purpose: This study evaluates the acceptance of GPS/GPRS-based telematics technology in freight road transport companies registered in Poland.
Design/methodology/approach: The evaluation is based on a survey of 500 representative road transport companies carried out in 2020. The Technology Acceptance Model was estimated, and its results were checked for robustness. The scope of the information collected in telematics systems is defined in terms of its perceived utility and perceived ease of use at the operational management level. The latent factors affecting technology use are defined and implemented.
Findings: Most respondents (80%) claimed that telematics systems had a considerable influence on the effectiveness and efficiency of the whole company's operation. It contributed to a higher number of orders executed per time unit, more effective use of the driver's working time, and increased the entrepreneurs' trust in the company. The companies employing more workers recognize the higher usefulness of telematics systems and are motivated to use the technology more widely than smaller enterprises. TAMs estimated separately for small and medium-sized enterprises did not significantly differ among the parameter estimates.
Research limitations/implications: The Technology Acceptance Model is a useful analytical tool for evaluating telematics technology acceptance by the road transport sector. The study is based on a random sample of enterprises observed once in 2020. It is recommended to monitor them in two or three waves to compare the dynamics of the telematics usage process. It is planned to continue the study in that direction.
Practical implications: The outcomes are valuable in practice twofold. Firstly, the extension of telematics systems use is interesting for final users, i.e., road transport companies that will find scope for their application. Secondly, the results are helpful for system providers who get knowledge on telematics perception from enterprise management.
Originality/value: Although widely applied to other IT systems, the TAM model has not been used to evaluate the use of telematics in road transport companies. The paper justifies TAM's categories at the operational management level in road transport enterprises, contributing to understanding managers' behavioral aspects of decision-making.

Keywords: Intelligent Transport Systems (ITS), Technology Acceptance Model (TAM), Structural Equation Model (SEM), road transportation, small and medium enterprises.

Category of the paper: research and conceptual paper.

1. Introduction

This paper aims to evaluate the acceptance and the actual utilization of GPS/GPRS-based telematics technology in road transport companies registered in Poland. The motivation is two-fold. Firstly, it is interesting to find out managers' attitudes towards a wide use of intelligent transport systems (ITS) in the freight road transport sector, considering that the industry is dominated by small and medium enterprises (SMEs). Secondly, the results obtained in the study carried out in 2019 on the extent of telematics equipment utilization to support transport and management processes revealed that, on the one hand, the solutions are omnipresent. Still, on the other hand, the offered functionalities are used only to a certain degree, including but not limited to supporting transport and management processes (Zalewski, 2019; 2020). Therefore, another survey was designed and carried out in 2020. It was aimed to answer the question concerning the scope of telematics systems utilization in the operational management process and the internal and external factors affecting their use. Internal factors mean the factors that originate from the company, while the external ones are the stimuli from the company's environment. As a result of the COVID19 pandemic, many companies shifted to remote work, and all parties: contractors, clients, and clerks have gotten used to electronic documents. As a result, the scale of using systems integrated with telematics systems in road transport has increased significantly. Still, the answer to whether internal factors provided sufficient support for the use of telematics-management tools will be possible only after the ex post analysis.

Telematics consists of data collection, processing, and output which achieves goals using sensors, information and communication technology, and mathematical models (Bäumler & Kotzab, 2017). The authors distinguished the following areas of using telematics for freight road transport: fleet management, toll collection and control, tracking and tracing, emergency and disturbance management, control of public traffic systems, provision of traffic information, control of hazardous goods and heavy bulk transports, and primary traffic control units. Lewiński & Perzyński (2019) indicated the following applications of telematics for road transportation: navigation, vehicle management and control, vehicle communication, passenger information, traffic and control management, driver communication, weather information, and traffic route information. Above these, they emphasized that telematics allows for optimizing transport management and increasing the efficiency of transport means.

The terminology used in the study resulted from the structure of the Technology Acceptance Model (TAM; Davis, 1985). It enables the identification of the cause-and-effect relationships between the perceived usability and the ease of telematics systems' use and the attitude towards the use and the actual use. The advantages of the TAM are the possibility of identifying direct and indirect cause-and-effect relationships and extending the model with subsequent factors that affect the telematics systems' use. Regarding the fact that most road transport companies are micro-companies or small and medium-sized enterprises (SMEs), the assumption was made in the study that the discussed cause-and-effect relationships can depend on the company size. According to research on SMEs, it can be assumed that due to limited resources, there are significant differences in SMEs management methods compared to big companies that most management theories apply to (Analoui & Karami, 2003; Rajesh, Pillania, 2008). A critical indication comes from the findings reported by Turner, Ledwith & Kelly (2009). They examined 118 respondent companies, divided into micro-companies and SMEs, and hi-tech, low-tech, and service industries. They found that companies of all sizes spend roughly the same proportion of their turnover on projects, but the smaller the company, the smaller its projects are, and the less it uses project management and its tools. Strangely enough, hi-tech companies spend less on projects than low-tech or service companies but have more extensive projects and use project management to a greater extent.

Considering these findings and implementing the road transport industry's characteristics, we assumed that micro and small transport enterprises are less likely to benefit from telematics systems due to lower knowledge of their application in transport activity management. Therefore, the enterprise size measured by the number of employees became an additional variable in the Technology Acceptance Model.

Our paper contributes to the existing literature in a novel way of examining the degree of telematics integrated technologies acceptance and utilization by road transport enterprises registered in Poland but operating in entire Europe. To the best of our knowledge, there is no similar research in any publications. Here, we focus on the enterprise's management level. Typically a single user (an individual) is asked to demonstrate or compare their motivation to use a given application. Thus, managers are responsible for using telematics devices and integrated packages for the company's operational management. So an enterprise was defined as a microunit. We do not consider any particular product. We analyze how much the enterprises realize that they benefit from this kind of support. Since the Polish road transport sector (along with the German and British ones) is among the most significant transport stakeholders in Europe and has the newest generation of trucks and semitrailers, the findings and conclusions can be easily extended (EU Transport and figures, 2020). Another incentive to take advantage of the new solutions is that the questionnaires were collected during the first phase of the COVID19 pandemic. Recent organizational and legal circumstances contributed to an increase in the popularity of hi-tech devices. The study examined 500 enterprises that responded to the questions in June-July, 2020.

2. Technology Acceptance Model and its assumptions

In 1985 Davis presented The Technology Acceptance Model (TAM) concept (Davis, 1985). It was based on the assumption that a decision about using new information technology is the user's behavioral reaction that can be explained or even predicted based on the user's motivation; the motivation is, in turn, affected directly by external stimuli resulting from the technology's current features and capabilities, the user's characteristics and organizational factors (Venkatesh & Davis, 2000). The technology acceptance is meant as a will, demonstrated in the users' group, to use the information technology to implement the technology's tasks (Dillon & Morris, 1998).

Based on these assumptions, Davis extended his conceptual model to the version shown in Figure 1.

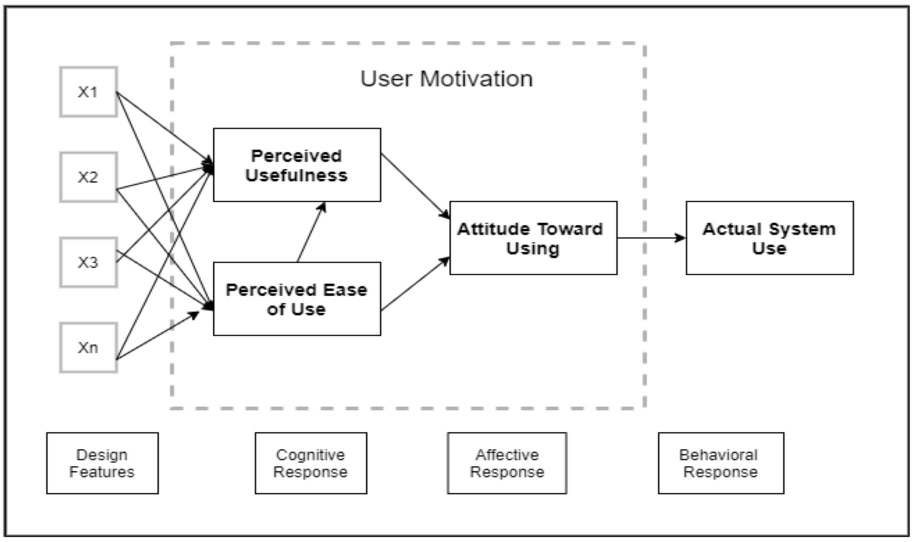

Figure 1. Technology Acceptance Model – a diagram based on Davis (1985).

Davis intended to develop a simple, theoretically justified model capable of explaining the factors that determine computer systems' use in general, i.e., for different users' end groups and different system types. He assumed that the user's attitude toward technology is the primary determinant of either using or rejecting the system. He proposed that the user's motivations can be explained by the three main factors: Perceived Ease of Use (PEU), Perceived Usefulness (PU), and Attitude Toward Using (ATU), which are latent variables. Davis also claimed that the user's attitude is affected by two convictions: Perceived Usefulness and Perceived Ease of Use, whereby the latter directly influences Perceived Usefulness. Moreover, it was assumed that the system design features (marked as X1, X2, X3 to Xn in Figure 1), also referred to as external variables, directly impact the two convictions. The TAM is then a theoretical base that explains how different factors affect the convictions, attitudes, and intentions (Davis, 1989, p. 985).

The original model developed by Davis in 1985 has been subjected to many transformations and extensions. Venkatesh & Davis (2000) proposed the TAM2 model, which provided a more accurate and detailed explanation of the reasons why some users accepted the use of the particular system or technology concerning time, namely before the implementation, one month after the implementation, and three months after the implementation.

Venkatesh & Bala (2008) combined TAM2 and the Perceived Ease of Use determinants model (Venkatesh, 2000) to develop an integrated technology acceptance model known as TAM3. The authors completed the system/technology Ease of Use determinants catalog in this model.

Further studies carried out to modify the TAM model and adapt it to the changing reality led to the development – by Venketesh et al. – of a uniform theory of technology acceptance and use, which was the base for The Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003).

There is an abundance of papers devoted to TAM and its modifications. Analyzing two databases, i.e., Web of Science and Scopus, for the period between 1997 and 2020 and searching according to the paper title, abstract, keywords, and text content for the "Technology Acceptance Model" phrase, we get the search result of 18,845 papers in Web of Science and 14,429 papers in Scopus.

It shall be concluded that the number of papers and their topics is highly diversified. Many journal articles related to GPS/GPRS telematics systems and Global Navigation Satellite System (GNSS) refer to technical descriptions and simulations of the systems. Humphreys et al. (2020) examined the effectiveness of the GNSS system for high-level accuracy in positioning objects in a deep urban setting unaided by complementary sensors. Kassas et al. (2020) provided a framework for ground vehicle localization that uses cellular signals of opportunity, a digital map, an inertial measurement unit, and a Global Navigation Satellite System (GNSS) receiver. This framework enables localization in an urban environment where GNSS signals could be unusable or unreliable. The results helped much in reducing localization errors. Fernandez-Hernandez et al. (2020) focused on a high-accuracy service (HAS) provided by the Global Navigation Satellite System.

There are no papers on the acceptance of telematics technologies in road transport. An analysis of the journals' databases indicates that despite high popularity and many studies carried out on technology acceptance, only a few were devoted to telematics as a modern technology discipline. Another analysis of Scopus and Web of Science databases, using a similar search method but based on the phrases "Technology Acceptance Model in Telematics" or "Technology Acceptance Model & Telematics Systems & Road Transport," rendered only 11 papers in Scopus and 54 ones in Web of Science. The papers' content analysis revealed that they did not apply directly to the issues related to GPS/GPRS-based telematics technologies used by road transport enterprises. Nevertheless, they contributed to assessing individual perceptions of innovative solutions in transportation.

Chen & Chen (2011) analyzed factors affecting the travelers' intentions related to the use of GPS products and systems installed in vehicles. The survey questionnaire was designed based on the Technology Acceptance Model (TAM) and the unique properties of GPS equipment.

The results revealed that the Perceived Ease of Use had a significant and positive impact on Perceived Usefulness. Every Perceived Usefulness, Perceivable Pleasure of Use, and Ease of Use have a significant positive influence on the Attitude Towards Using. The Attitude Toward Using significantly affects the behavioral intention and will to use. Personal innovativeness moderates the relationship between attitude and behavioral intention.

Park et al. (2012) carried out a study on 1,011 participants and used the Structural Equations Model (SEM) to establish the technological acceptance criteria for the applied mobile map services. The study results revealed that the Perceived Mobility and the Perceived Location Accuracy significantly affected the users' acceptance of their intention to use mobile map services via computer equipment. An increase in Perceived Mobility positively affected the Perceived Usefulness and Ease of Use of the services. Moreover, the study revealed a more substantial influence of the approach on behavioral intention than the Perceived Usefulness.

Nordhof et al. (2020) reported on the study of social acceptance for using partially automated and autonomous passenger vehicles. The Unified Theory of Acceptance and Use of Technology (UTAUT2) was used to investigate the effects of the capacity and expected effort, social impact, facilitating factors, and hedonic motivation on the behavioral intention to use partially automated vehicles. A survey was carried out on 9,118 drivers in eight European countries. 71.06% of the respondents decided that partially automated cars are easy to drive, and 28.03% of the study participants intend to buy an automated car when it is available.

Recently, Yang et al. (2021) have proposed an integrated technology acceptance model to investigate the factors which affect drivers' intention to use mobile navigation applications, which can also apply to road transport. The vital element included optimizing mobile applications by programmers so that apps did not distract the driver's attention while driving a vehicle. The study was carried out on a population of 384 drivers.

3. TAM in the assessment of telematics acceptance by road transport enterprises

In the paper, we constructed the Technology Acceptance Model and proposed its modification taking into account the original Davis's motivation. As we decided to study the companies from the road transport sector, we assumed that our targets are defined as these companies' managers and owners. Thus, we can assume that they possess broader knowledge than the end-users of the typically employed systems in these companies. So the model construction was projected at the management level. Therefore the Perceived Use was defined as the Perceived Usefulness of information coming from intelligent transport systems (ITS) for the operational management of the transport processes observed in the company.

Consequently, the Perceived Use (PU) latent variable was described by increasing the system's efficiency in the following areas: the number of orders, timeliness, market confidence, costs control, and profitability of orders. The Perceived Ease of Use (PEU) was defined by retracing the routes, truck punctuality in the sender's and receiver's locations, time delays reporting, driving time analysis, and fuel consumption. It is related to the standard scope of investigation in transport activity within Transport Management Systems (TMS). Moreover, it was assumed that the telematics system enables preparing analysis in a more precise, convenient, and fast way than standard office tools. It can be noticed that PU and PEU are defined by internal features that come from the enterprise. The following variable – Attitude Toward Use (ATU), covers external components from the enterprise's environment. The following characteristics define the Attitude Toward Use: the significance of information coming from telematics systems, the safety of data collected in the telematics system, and the level of autonomy in making decisions about using a telematics system. The latter concerns the links in the supply chains where a given transport enterprise operates. The actual use was observed as a practical use of the system.

The observed characteristics are thus closer to the manager's observations in the enterprise than individual psychological features, as was reported by Davis (1985) and former papers utilizing the TAM theory. A cognitive feature such as Perceived Use is thus related to the manager's Perceived Usefulness. The Perceived Ease of Use could be reported by managers as well as individual employees who use the system. The Attitudes Towards Use are based on the managers' perception concerning facts and belief in the system's data protection power. In this context, we perceive managers as the enterprise's rational (or informed) power, considering both advantages and costs of telematics systems utilization. Furthermore, the company's environment (contractors) requirements may increase interest in employing a broader scope of telematics.

Previous studies (Zalewski, 2019; 2020) revealed that enterprises applied telematics systems to track vehicle routes. Other advantages of the system included analyzing the drivers' working time in a given 24-hour driving period and forecasting whether the driver will be able to arrive at the destination within the pre-determined time slot for loading or unloading. Compatibility of telematics systems with cargo exchanges and clients applications, and compatibility with other onboard devices, e.g., refrigeration units, is a basis of proper communication.

Recently, when the COVID19 pandemic has changed the reality, entrepreneurs became aware that telematics offers more than truck tracing. That is why the study can be treated as reliable because the managers realized the system's advantages. One issue needs to be explained, though. The enterprises use telematics systems for different periods, ranging from several months to several years. We assumed they reported the system's usefulness as they had assessed it for the survey time. To prepare the Technology Acceptance Model for telematics, we developed a survey questionnaire. The respective questions are described in Appendix 1.

4. Data characteristics

The survey, which aimed to identify the factors of telematics technology acceptance, was conducted in June-July, 2020 among 500 randomly selected road transport enterprises that carry goods using the CATI method. The surveyed units were defined for the material criterion, i.e., enterprises providing road transport services, and territorial criterion, i.e., enterprises whose business activity is registered in Poland. The survey was carried out based on a sample of enterprises from the databases of the members of the Association of International Road Carriers in Poland. Consequently, the enterprises were selected from a population of 4,500 companies. The fact that decision-makers took part in the study (they were managers competent in the scope of the answers provided) was a vital aspect of the study. The statistical assumption determined the number of 500 respondents that the maximum error rate in the estimation would not exceed 5% (Aczel & Sounderpandian, 2002). The structure of the sample is presented in table 1.

Table 1.
Structure of the studied sample

Participation of enterprises by the form of conducted activity	**%**	**Share of enterprises by the number of employees**	**%**
Sole proprietorship	2.20	1 to 9	6.60
Limited liability company	80.80	10 to 49	56.00
General partnership	13.80	50 to 249	32.40
Joint-stock company	2.20	Over 250	5.00
Other (limited partnership)	1.40		
Participation of enterprises by the homogeneity of the conducted business activity	*%*	*The range of services provided*	*%*
At least 80% of revenues generated from transport activities	74.20	International	66.20
Less than 80% of revenues generated from transport activities	25.80	Domestic	23.40
Participation of enterprises by experience in running a business	*%*	Regional Local	7.10 3.30
More than 10 years From 5 up to 10 years From 3 up to 5 years Up to 3 years	95.00 2.80 1.20 1.00		

The data presented in Table 1 reveal that the sample of 500 enterprises selected for the study roughly reflects the structure of transport enterprises providing domestic and international transport services, in line with the data presented in the report (GITD 2020). An analysis of the survey data revealed that all enterprises participating in the survey had vehicles with telematics systems installed. All surveyed enterprises owned 24,975 vehicles, 97.3% of which were equipped with a telematics system (24,304 vehicles). Enterprises used a wide range of different telematics products, such as TomTom (20%), Navi Expert (17%), MIX Telematics (13%), Fleetmatics (13%); however, no significant dominance of any product was observed.

5. Empirical results

5.1. Measurement constructs in the TAM model

The list of all survey questionnaire questions analyzed in the paper is included in Appendix 1. A relevant designation of the variable x_i, i = 1 … 14 was assigned to the questions used to define and construct the latent variable. According to the definition proposed by Davis, the usefulness of the telematics technologies used in the enterprise should reflect the degree of the users' conviction that the technologies will improve the results of the users' work or help achieve a much higher operating capacity owing to the use of specific technology. The Perceived Usefulness of the telematics system was explained in the study by determining how it improves the enterprise's performance by increasing the system's efficiency in the following areas: the number of orders, timeliness, market confidence, costs control, and profitability of orders. The measurement method of the Perceived Usefulness (PU) and Perceived Ease of Use (PEU) variables was discussed in the previous section. It was assumed in the study that the Attitude Toward Using (ATU) for telematics systems must not be identified only with the concept of autonomous rather than forced decision concerning their implementation in the company. Therefore, it includes the safety of telematics systems perceived by the users and the awareness of the system's usefulness for the company's operation. The observable variables for this factor were marked as x11, x12, and x13. Only the resultant variable in the TAM – the Actual System Use (USE) – was reflected directly in the survey questionnaire, in the question applying to the degree of using the telematics system in the company (x14). It is the only observable variable.

All analyzed factors – latent variables included in the TAM, i.e., PU, PEU, and ATU – were verified for scale reliability. Cronbach's alpha (CA) statistics for PEU and PU are much higher than the recommended value of 0.7, which means satisfactory scale reliability (Cortina, 1993). The CA statistics values are higher than the required level, only for the ATU variable; the statistics value is slightly lower. Still, the difference is slight and amounts to ca. 6% of the recommended value. That is why the ATU variable was included further in the analysis.

Table 2.
Summary of latent variables and reliability statistics (AC)

Latent variable	Variables	Cronbach's alpha statistics (AC)
PEU (Perceived Ease of Use)	x_1, x_2, x_3, x_4, x_5,	0.847
PU (Perceived Usefulness)	x_6, x_7, x_8, x_9, x_{10}	0.847
ATU (Attitude Toward Using)	x_{11}, x_{12}, x_{13}	0.661
USE (Actual Use of the System)	x_{14}	NA

5.2. Estimated TAMs

Structural Equation Modeling (SEM) methodology was used to determine the relationship between Perceived Usefulness (PU), Perceived Ease of Use (PEU), Attitude Toward Using (ATU), and Actual System Use (USE) according to TAM. The models enable the analysis of cause-and-effect relationships between the latent variables, which cannot be measured directly (Bollen, 1989; Pearl, 2000; Byrne, 2010).

Two TAMs were estimated in this paper – a classical and extended one in which an additional variable was included. The company size was the new variable, measured directly with the workforce number (EMP variable). Both models were estimated in the SPSS AMOS v.16 package with the maximum likelihood (ML) method. A significance level of 0.05 was assumed for statistical analysis. Above these, the classical TAM was also estimated in two variants: for small enterprises (headcount up to 49 people) and medium-sized enterprises (headcount of 50 or more people). The estimation results for all TAM variants are summarised in table 3.

Table 3.
Estimated TAM models

Relations	**Estimate**	**SE.**	**p-value**
Classic TAM model (total sample)			
PEU → PU	0.526	0.050	0.000
PEU → ATU	-0.077	0.039	0.258
PU → ATU	0.374	0.048	0.000
ATU → USE	0.763	0.140	0.000
CMIN/DF = 2.023 IFI = 0.969 RMSEA = 0.045			
Extended TAM model (total sample)			
EMP → PU	0.147	0.000	0.000
EMP → ATU	0.174	0.000	0.000
PEU → PU	0.523	0.050	0.000
PEU → ATU	-0.065	0.039	0.340
PU → ATU	0.338	0.048	0.000
ATU → USE	0.762	0.138	0.000
CMIN/DF = 1.917 IFI = 0.968 RMSEA = 0.043			
Classic TAM model for micro and small enterprises			
PEU → PU	0.513	0.063	0.000
PEU → ATU	-0.036	0.045	0.670
PU → ATU	0.306	0.055	0.001
ATU → USE	0.756	0.211	0.000
CMIN/DF = 1.824 IFI = 0.961 RMSEA = 0.052			
Classic TAM model for medium-sized enterprises			
PEU → PU	0.562	0.085	0.000
PEU → ATU	-0.132	0.066	0.255
PU → ATU	0.437	0.083	0.000
ATU → USE	0.762	0.198	0.000
CMIN/DF = 1.525 IFI = 0.957 RMSEA = 0.053			

The results obtained for the total sample of enterprises confirm the statistically significant influence of the Perceived Ease of Use (PEU) on the Perceived Usefulness (PU), the Perceived Usefulness on the Attitude Toward Using (ATU), and the Attitude Toward Using on the Actual

Use of the System (USE). It means that the less complicated the system (PEU), the higher its Perceived Usefulness (PU) is. As the Perceived Usefulness (PU) increases, the greater the motivation to use it (ATU) is, which contributes to the actual broader use of telematics systems (USE). The relationship between the Perceived Ease of Use (PEU) and Attitude Toward Using (ATU) is statistically insignificant.

Based on the results obtained for the extended TAM, it can be reasoned that the companies that employ more workers (EMP) recognize the higher usefulness of telematics systems (PU) and are motivated to have the systems (ATU) more than smaller enterprises. The results comply with the authors' intuition and experience in the field. However, TAMs estimated for small and medium-sized enterprises did not reveal any significant differences in the parameter estimates. The only major difference in the parameter evaluation for both groups was observed for the PU → ATU relationship and amounted to 0.131 (0.437-0.306 difference). The calculated statistics $t = 1.316$ ($p = 0.188$) does not allow for evaluating the difference as statistically significant (Weaver & Wuensch, 2013). It is the stability of the parameter estimates across the samples used in research that matters.

The CMIN/DF statistics values lower than 2, IFI higher than 0.95, and RMSEA less than 0.05 are a testimony of a perfect adaptation of the models to the data (Żurek, 2016). Only for models based on subgroups defined by the number of employees the value of the RMSEA coefficient is slightly higher. For both groups, it is lower than 0.055, so it confirms that the model is well fitted to the data.

6. Robustness check

Despite the correct statistics confirming the model's quality, the results were additionally verified. A bootstrap procedure using the maximum likelihood (ML) estimator was employed to re-estimate the model parameters. The procedure was used for the model estimated based on the total sample. The bootstrap based on 5,000 samples helped calculate the parameter bias and standard errors of the biases, and determine the bias-corrected confidence intervals of 95% (Efron, Tibshirani, 1986). The results for internal TAMs are summarised in table 4.

Table 4.
Results of TAM estimation with the bootstrap methodology

Relations	Estimate	Bias	S.E. Bias	Lower	Upper	p-value
Classic TAM model (total sample)						
PEU → PU	0.526	0.004	0.001	0.441	0.614	0.000
PEU → ATU	-0.077	0.000	0.001	-0.213	0.054	0.315
PU → ATU	0.374	-0.001	0.001	0.232	0.517	0.000
ATU → USE	0.763	-0.005	0.001	0.698	0.810	0.000

Cont. table 4

Extended TAM model (total sample)						
EMP → PU	0.147	0.000	0.000	0.087	0.216	0.001
EMP → ATU	0.174	0.000	0.000	0.105	0.236	0.001
PEU → PU	0.523	-0.003	0.001	0.436	0.609	0.000
PEU → ATU	-0.065	0.000	0.001	-0.198	0.061	0.371
PU → ATU	0.338	-0.001	0.001	0.203	0.487	0.000
ATU → USE	0.762	0.021	0.003	0.697	0.808	0.000

Based on the results, the parameters reflecting the influence of the employment (EMP) variable on the PU and ATU for the extended model were unbiased. The presence of the model parameters bias does not prejudge a lack of statistical significance. The parameter bias value is assumed to be statistically insignificant when the standard bias error is greater than the bias (absolute value) (Byrne, 2010). It is valid for the PEU → ATU relationship in both estimated models. The confidence intervals corrected with the bias confirm the reliability of the parameters estimated with the maximum likelihood method (PEU → PU; PU → ATU; ATU → USE). The confidence level determined for the PEU → ATU relationship includes zero value in both models, suggesting the parameter's insignificance analogically to the findings made with the maximum likelihood method. Hence, the ML estimated models' results and verified with the bootstrap enable reliable inference based on the models.

7. Discussion

The Technology Acceptance Model is a useful analytical tool for evaluating telematics technology acceptance by the road transport sector for two reasons. First and foremost, the model is very well rooted in the behavioral context, particularly in the Theory of Planned Behavior (Ajzen, 1991). Secondly, it is universal, which means it can be used on different analysis levels. A short note about the usefulness of the TAM in cognition should be made. Based on the argumentation that TAM methodology is saturated, Benbasat & Barki (2007) formulated five recommendations to take the IT adoption literature beyond TAM to the next generation of adoption and acceptance research. They are the following: going back to the Theory of Planned behavior, a better conceptualization of system usage to include a broader perspective of what users do in and around the notion of system use, using multi-stage models to capture the influence of salient belief variables on system use at different stages of implementation, and the subsequent impact of this usage on users' beliefs at later periods, identifying the antecedents of the views contained in adoption models to benefit practice and finally making sure usefulness is measured beyond perceptions where possible. We believe that we adopted two of these recommendations. Firstly, system usage was the observed variable. It was verified by additional information about the area of systems application. Secondly, based on using telematics systems for a long time before the study, their usefulness was already justified.

The results obtained for the studied enterprises (total sample and divided into micro, small and medium-sized enterprises) confirm a statistically significant impact of the Perceived Ease of Use (PEU) on the Perceived Usefulness (PU), the Perceived Usefulness on the Attitude Toward Using (ATU) and the Attitude Toward Using on the Actual Use of the System (USE). It means that the less complicated the system (PEU), the higher its Perceived Usefulness (PU) is. Simultaneously, as the Perceived Usefulness (PU) increases, the greater the motivation to use it (ATU), which contributes to the actual broader use of telematics systems (USE). The relationship between the Perceived Ease of Use (PEU) and Attitude Toward Using (ATU) is statistically insignificant, which may be attributed to the fact that business entities have been using ICT technologies for quite a long time, and their scope has been extending gradually. Hence, the Perceived Ease of Use may slightly lose its significance versus the Perceived Usefulness as the factor determining the use of the enterprise's telematics system. Adequate service and support for the institution implementing the system may significantly mitigate the potential difficulty. An analysis of the sensitivity of the results confirmed their stability and reliability.

The model extended by a company size confirmed that small and medium companies utilize information from the telematics systems in the operational management process. However, medium companies do it more widely and frequently. It is in line with the observed fact that small enterprises are less vulnerable to digital transformation (Probst et al., 2017; Fischer et al., 2020).

As was mentioned in the introduction, the area and level of telematics systems application were the subject of previous research carried out in 2019 among road transport companies (Zalewski, 2020). The scope and level of telematics solutions advancement in road transport companies were analyzed in the research for the barriers to their use and clients' requirements. The results suggested that the obstacles to using telematics devices are strongly related to the contractors' requirements, which is linked to the scope of the devices' use by road transport companies. An increase in the range of telematics device use contributed to a rise in the added value in the enterprises.

Research in 2020 revealed a significant change in the level of telematics device use and motivation to use them. Most respondents (80%) claimed that telematics systems had a considerable influence on the effectiveness and efficiency of the whole company's operation. It contributed to a higher number of orders executed per time unit, more effective use of the driver's working time, and increased the entrepreneurs' trust in the company. A comparative assessment of the 2019 and 2020 research reveals a substantial change in the perception (attitude), application, and use of telematics systems.

The pandemic conditions completely changed the attitude toward telematics systems and forced moving many operations to ICT platforms, often based on remote solutions. It can be regarded as a positive effect of the pandemic, considering the Shumpeterian' creative destruction' (Freeman, 2009). Such solutions seem to be long-lasting, which will cause a significant change in the manager's approach to the employed solutions in a long-term perspective. As Contractor (2021) argues, after the pandemic, businesses are facing implementing better information-gathering systems, 5G surveillance and monitoring, blockchain, and other integration of vendor–buyer computer systems. Looking closer into the European environment after Brexit, the changing transport requirements promote the long-lasting use of the reference solutions (Moskal, 2018). For these reasons, the conclusion is that enterprises using telematics systems are subject to advantages for vehicle tracing and operational management and external incentives caused by supply chains requirements and unexpected shocks.

8. Conclusion

This study's subject matter focused on assessing the acceptance level of GPS/GPRS-based telematics technology by road transport companies. The Technology Acceptance Model (TAM) was used for this purpose. Despite a broad scope of the TAM applications in the original version proposed by Davis in 1985 and its numerous modifications, the literature makes no mention of research on the acceptance of telematics technologies linked with road transport management systems. This study fills the gap. Our study proposed using a classical and extended (to include workforce number) TAM; we also estimated TAM models by micro, small, and medium-sized enterprises.

A random sample of 500 road transport companies registered in Poland was used for the study. Considering the scale and range of the transport operations performed by Polish transport companies all over Europe and their similarity in equipment modernity, the scope of the process, and size, the companies were selected correctly, which enables making generalizations on the European scale.

The (latent) measurement variables construct is applied to the enterprise level. The obtained empirical results turned out to be stable and cohesive for all estimated models. The following sequence of cause-and-effect relationships was established: PEU → PU → ATU → USE. The estimated models revealed adequate values of statistical indicators and resistance to potential bias. The results confirmed that road transport companies utilize information from telematics systems to improve their efficiency.

Comparing the results with the results of research carried out in 2019 indicates that the pandemic effect was observed in 2020, which involved broader use of ICT applications and devices, including telematics ones, by road transport companies. A forced implementation combined with an operational effectiveness analysis caused a significant qualitative change in transport service. It is a positive and probably long-lasting effect because micro and small enterprises need more time to implement digital solutions, often requiring extra expenditures.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Aczel, A.D., Sounderpandian, J. (2002). *Complete Business Statistics.* Boston, Mass: McGraw Hill/Irwin.
2. Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes, 50, 2,* 179-211 https://doi.org/10.1016/0749-5978(91)90020-T.
3. Analoui, F., Karami, A. (2003). *Strategic Management in Small and Medium Enterprises*. University of Bradford.
4. Bäumler, I., Kotzab, H. (2017). Intelligent Transport Systems for Road Freight Transport—An Overview. In: M. Freitag. H. Kotzab, J. Pannek (eds), *Dynamics in Logistics.* Springer. http://dx.doi.org/10.1007/978-3-319-45117-6_25.
5. Benbasat, I., Barki, H. (2007). Quo vadis TAM? *Journal of the Association for Information Systems*, *8(4),* http://dx.doi.org/10.17705/1jais.00126.
6. Bollen, K.A. (1989). *Structural Equations with Latent Variables.* New York: Wiley.
7. Byrne, B.M. (2010). Structural equation modelling with AMOS. New York: Routledge, https://doi.org/10.4324/9780203805534.
8. Chen H.-H., Chen, S.-C. (2011). Applying the TAM to travellers' usage intentions of GPS devices. *Expert Systems with Applications*, *38(5),* 6217-6221, http://doi.org/10.1016/j.eswa.2010.11.047.
9. Chen H.-H., Chen, S.-C. (2009). The empirical study of automotive telematics acceptance in Taiwan: comparing three Technology Acceptance Model. *International Journal Mobile Communications, 7(1),* https://doi.org/10.1504/IJMC.2009.021672.

10. Davis, F. (1985). *A technology acceptance model for empirically testing new end-user information systems: theory and results*. Cambridge, MA: MIT Press.
11. Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13(3),* 319-340. https://doi.org/10.2307/249008.
12. Dillon, A., Morris, M. (1998). *From "can they" to "will they?": extend¬ing usability evaluation to address acceptance.* E. Hoadley, I. Benbasat (eds.). Proceedings of the Fourth Americas Conference on Information Systems (AMCIS). Baltimore: Univ. of Baltimore. http://aisle.aisnet.org/amcis1998/325.
13. Efron, B., Tibshirani, R. (1986). Bootstrap Methods for Standard Errors, Confidence Intervals, and Other Measures of Statistical Accuracy. *Statistical Science*, *1(1),* 54-75.
14. *EU Transport and figures* (2020). https://op.europa.eu/en/publication-detail/-/publication/da0cd68e-1fdd-11eb-b57e-01aa75ed71a1, 02.02.2021.
15. Fernandez-Hernandez, I., Senni, T., Calle, D., Cancela, S., Vecchione, G.A., Seco-Grandos, G. (2020). Analysis of High - Accuracy Satellite Messages for Road Applications. *IEEE Intelligent Transportation Systems Magazine*, *12, (3),* 92-108, https://doi.org/10.1109/MITS.2020.2994074.
16. Fischer, M., Imgrund, F., Janiesch, C., Winkelmann, A. (2020). Strategy archetypes for digital transformation: Definingmeta objectives using business process management, *Information & Management, 57, 5,* 103262, https://doi.org/10.1016/j.im.2019.103262.
17. Humphreys, T.E., Murrian, M.J., Narula, L. (2020). Deep-Urban Unaided Precise Global Navigation Satellite System Vehicle Positioning. *IEEE Intelligent Transportation Systems Magazine*, *12, 3,* 109-122, 2020. https://doi.org/10.1109/MITS.2020.2994121.
18. Kassas, Z.Z.M., Maaref, M., Morales, J.J., Khalife, J.J., Shamei, K. (2020). Robust Vehicular Localization and Map Matching in Urban Environments Through IMU, GNSS, and Cellular Signals. *IEEE Intelligent Transportation Systems Magazine*, *12, 3,* 36-25, https://doi.10.1109/MITS.2020.2994110.
19. Lewiński, A., Perzyński, T. (2019). Telematics as a New Method of Transport System Safety Verification. *Research Methods and Solutions to Current Transport Problems*, 266-273. https://doi.org/10.1007/978-3-030-27687-4_27.
20. Moskal, A. (2018). The Impact of Brexit on the European Union's Future Development in the Context of European Integration. *Torun International Studies*, *1(11),* 25-36. http://dx.doi.org/10.12775/TIS.2018.002.
21. Nordhof, S., Louw,T., Innamaa,S., Lehtonen, E., Beuster, A., Torrao, G., Bjorvatn, A., Kessel, T., Malin, F., Happee, R., Merat, N. (2020). Using the UTAUT2 model to explain public acceptance of conditionally automated (L3) cars: A questionnaire study among 9.118 car drivers from European countries. *Transportation Research Part F, 74,* 280-297. https://doi.org/10.1016/j.trf.2020.07.015.

22. Park, E., Kim, K.K., Jin, D., del Pobil, A.P. (2012). Towards a successful mobile map services: An Empirical Examination of Technology Acceptance Model. *International Conference on Networked Digital Technologies*, 420-428. https://org/10.1007/978/-3-642-30507-8_36.
23. Pearl, J. (2000). *Causality.* New York: Cambridge University Press.
24. Probst, L., Pedersen, B., Lonkeu, O., Martinez-Diaz, K., Araujo, C., Klitou, L.N., Rasmussen, M. (2017). Digital Transformation Scoreboard 2017: Evidence of positive outcomes and current opportunities for EU businesses. *The European Commission*.. https://ec.europa.eu/docsroom/documents/21501/attachments/1/translations/en/renditions/pdf, 10.2021.
25. Rajesh, K. Pillania (2008). Strategic issues in knowledge management in small and medium enterprises *Knowledge Management Research & Practice*, *6,* 334-338. https://doi.org/10.1057/kmrp.2008.21.
26. Turner, J.R., Ledwith, A., Kelly, J. (2009). Project management in small to medium-sized enterprises: A comparison between firms by size and industry. *International Journal of Managing Projects in Business*, *2(2),* 282-296. https://doi.org/10.1108/17538370910949301.
27. Venkatesh, V., Davis, F.D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46(2),* 186-204. https://doi.org/10.1287/mnsc.46.2.186.11926.
28. Venkatesh, V. (2000). Determinants of perceived ease of use: integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research*, *11(4),* 342-365. https://doi.org/10.1287/isre.11.4.342.11872.
29. Venkatesh, V., Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Science*, *39(2),* 273-312. https://doi.org/10.1111/j.1540-5915.2008.00192.x.
30. Venkatesh, V., Morris, M.G., Davis, F.D., Davis, G.B. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, *27, 3*, 425-478. https://doi.org/10.2307/30036540.
31. Yang, L., Bian, Y., Zhao, X., Liu, X., Yao, X. (2021). Drivers' acceptance of mobile navigation applications: An extended technology acceptance model considering drivers' sense of direction, navigation application affinity and distraction perception. *International Journal of Human-Computer Studies, Vol. 145,* https://doi.org/10.1016/j.ijhcs.2020.102507.
32. Weaver, B., Wuensch, K.L. (2013). SPSS and SAS programs for comparing Pearson correlations and OLS regression coefficients. *Behavavior Research Methods, 45,* 880-895. https://doi.10.3758/s13428-012-0289-7.
33. Zalewski, W. (2019). Telematics systems in road transport. *Journal of Positive Management*, *10(1),* 3-20, http://dx.doi.org/10.12775/JPM.2019.001.

34. Zalewski, W. (2020). *Advantages and limitations to application of telematics systems in the road transport industry in Poland.* 36th International Business Information Management Association Conference (IBIMA), Granada, Spain, 4-5 November 2020. ISBN: 978-0-9998551-5-7.
35. Żurek, M. (2016). *Behavioral inclinations in financial markets in the light of SEMs* (In Polish), Torun: NCU Publishing House.

Appendix I

Survey questionnaire questions (Likert Scale 1-7; 1 – No Impact, 7 – Significant Impact)

Factor	Question	Variable
PU	How much does your company's telematics system increase work effectiveness in respect of the following factors? • Contributes to a higher number of orders executed per time unit (e.g., month)	x_6
	• Improves the timeliness of tasks execution	x_7
	• Increases the contracting parties' trust in the company	x_8
	• Enables cost control on a current basis	x_9
	• Improves the orders' profitability	x_{10}
USE	How much do you use the telematics system, considering its technical capabilities?	x_{14}
PEU	Is the application of the telematics systems easy to learn, intuitive, and easy, and in what scopes? • Retracing the routes for all orders executed	x_1
	• Analysis of the vehicle's timely arrival for loading and unloading	x_2
	• Analysis of delays and their reporting to the contracting party	x_3
	• Analysis of the driver's working time in the last 24 hours, 7 and 14 days	x_4
	• Analysis of the vehicle's fuel consumption	x_5
ATU	• Is the knowledge acquired from the telematics system necessary for your company's operation on the transport market?	x_{11}
	• Specify the safety level of the data stored in the telematics system	x_{12}
	• Does the telematics system implementation in your company result from the company's autonomous decision or a necessity imposed by your contracting parties?	x_{13}