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CHANGES IN THE PERCEPTION OF TELEMATICS TECHNOLOGY BY ROAD TRANSPORT COMPANIES: AN EMPIRICAL ANALYSIS IN 2020-21

Summary. We present a novel study concerning the attitudes of road transport enterprises towards a broad application of telematics in operational management in road transportation. The study aims to assess telematics application in road transport and its changes over time while showing the factors most likely to determine the systems' use. Unobserved categories defined in the technology acceptance model (TAM) are adjusted to measure perceived usefulness, perceived ease of use, and attitudes toward using telematics systems by road transport managers. The study is based on 323 transport enterprises analyzed in two waves in 2020 and 2021. The use of two different time points is motivated by an observed increase in the digitalization of transport documents caused by the COVID-19 pandemic. The empirical findings support the TAM's usefulness in evaluating IT in transport business management. The findings also reveal that the significantly increased telematics use in 2020 was observed while it was endured. The results are checked for robustness and used for simulations. The study compares managers' behaviors over time and simulates the effect of individual (observed) variables on unobserved TAM categories.

1. INTRODUCTION

This paper focuses on the road transport industry, which is highly vulnerable to various external circumstances. The following reasons for this vulnerability are considered. Firstly, the road transport industry mainly belongs to the small and medium enterprises (SME) sector, and the share of large companies is relatively low. Therefore, the industry combines all SME sector advantages, like flexibility and low costs, and disadvantages, like scarce resources, vulnerability to worsening economic conditions, and high requirements related to sustainability challenges. Consequently, there is evidence that SME enterprises were particularly vulnerable to the COVID-19 pandemic [1].

Clampit et al. [2] focused on the dynamic capabilities of SME firms regarding how they anticipated the outcome. The empirical data analysis indicated that companies with a high efficacy of dynamic capabilities predicted the impacts related to their operations and revenues. Contrary to the global literature suggesting that enterprise size is positively correlated with the effectiveness of dynamic change in an enterprise, the authors found that this effect was reversed during the pandemic. This reversal resulted from the correlation between the efficacy of dynamic capabilities and enterprise performance, which was stronger in SME enterprises than in large companies.

Osińska and Zalewski [3] investigated the vulnerability and resilience of road transport enterprises in Poland to the economic crisis resulting from the pandemic's first phase. The empirical analysis based

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on the data observed in July 2020 revealed that this sector suffered much in this period. Medium-sized enterprises were more resilient than micro and small ones. On the other hand, micro-enterprises were supported by the government's anti-crisis policy.

Secondly, this sector is not particularly innovative apart from using a newer generation of transport units generating lower emissions. The transportation purpose is well-known, and only slight improvements in its organization can be made now. Many challenging issues are related to fully automated vehicles that are not yet available.

The present study deals with both issues. It aims to assess telematics technology solution applications in road transport enterprises due to the COVID-19 pandemic. We focused on telematics technology as the core technology for fleet management systems deploying data from the vehicle. On the other hand, transport management systems (TMSs) concentrate on transport order management between shippers and carriers [4]. It is essential to use both from the perspective of transport enterprises, but in this article, we report the results related to telematics systems based on digital platforms. The study is based on 323 transport enterprises observed in two waves in 2020 and 2021 (longitudinal data). It is assumed that the application of telematics technology solutions has been continuous for several years but that it intensified at the beginning of the pandemic (i.e., in the period from March-June 2020). Nevertheless, exploring telematics capabilities is essential to sustaining competition in the increasingly digital transport market and to use technological innovations for data-driven services to develop digital business models with new revenue streams. The digital transformation of transport services is enormous, and enterprises must adjust to the ubiquitous technology and select the optimum digital platform despite their size and potential.

The analytical tool used in this study is the technology acceptance model [5]. It allows the identification of cause-and-effect relationships between perceived usefulness, the ease of telematics technology systems' use, attitudes towards its use, and its actual use. Modern digital technologies in transport reduce operation costs by optimizing transport processes. The most powerful IT solution in transportation is telematics based on GPS/GPRS systems. A telematics system is an end-to-end system that provides communication, safety, security, and vehicle information services in a location-specific context. Implementing a system in an enterprise requires cooperation between vehicle manufacturers, telecommunications equipment manufacturers, carriers, and industry regulators [6].

Current and future technology developments depend on two factors: the development of technology determined by the technical knowledge level and the technology's adaptation and acceptance by its potential users. The current paper's novelty lies in its evaluation of the telematics solutions application in transport enterprises via the technology acceptance model (TAM). The enterprise's managers were asked about perceived utility, perceived ease of use, and motivation to use telematic systems for transport management. Unobserved categories defined in the TAM are adjusted to measure perceived usefulness, perceived ease of use, and attitudes towards using telematics systems by road transport managers and forwarders. Moreover, the changes between the two years are captured using longitudinal data gathered in 2020 and 2021. In this study, we analyze whether enterprises fully employ the benefits of telematics without considering a specific system. Furthermore, simulations based on the model revealed factors with the highest impact on particular variables. Thus, this study not only compares managers' behavior over time and simulates the effect of individual (observed) variables on unobserved TAM categories, but it also helps formulate practical implications.

The remainder of the paper consists of six sections. In Section 2, the model and research questions are defined. In Section 3, the sample is characterized. Section 4 presents empirical results for measurement models, final models, and robustness checks. Section 5 presents the results of simulations and predictions based on the model. The results are discussed in the context of the previous research in Section 6, while Section 7 offers a summary of this study and concluding remarks.

2. MODEL AND RESEARCH QUESTIONS

The technology acceptance model introduced by Davis [5] is the subject of much literature in theory and applications. The model assumes that a decision to use new information technology is the user's behavioral reaction and that it can be explained or predicted based on the user's motivation. The motivation, in turn, is directly affected by external variables resulting from the technology's current features and capabilities, the user's characteristics, and organizational factors. Technology acceptance is defined as the will demonstrated by users to apply information technology to implement the tasks that the technology was designed to support [7]. Davis intended to develop a simple, theoretically justified model that explains the factors that determine computer systems' use in general (i.e., for different user end groups and system types). The TAM is a theoretical base explaining how external factors affect convictions, attitudes, and intentions [8].

The original model has been subjected to many transformations and extensions. Venkatesh and Davis [9] proposed TAM2, which provides a more accurate and detailed explanation of why some users accept using a particular technology over time (i.e., before its implementation, as well as one month and three months after its implementation). TAM2 specified that users' mental assessments (related to the implemented goals of their work and the consequences of performing their duties) are a crucial element for formulating the perception level of a technology system's usefulness.

Venkatesh and Bala [10] combined TAM2 and the perceived ease of use determinants model to develop an integrated technology acceptance model recognized as TAM3. The model indicates the variables related to the differences between individual users, the system characteristics, social impact, and the facilitating elements, which are the determinants of perceived usefulness and ease of use. The authors generated this model's system/technology ease of use determinants catalog. They considered additional variables such as effectiveness, external perception of control, uncertainty, freedom, spontaneity, and objective usefulness. In TAM3, perceived ease of use (versus the perceived benefit), fear of using the system/technology (versus perceived ease of use), and behavioral intentions were moderated by the users' experience. Further studies have modified the TAM and adapted it to the changing reality, leading to a uniform theory of technology acceptance and use, which is the basis of the theory of acceptance and use of technology model [11].

The TAM is currently the most widely used technology acceptance model by individual and enterprise users [12]. Several extensions aim to increase the predictive power of the TAM [13] by adding variables that can tailor it to specific technologies (e.g., the use of integrated enterprise resources planning systems, contexts, and users) [14].

In this paper, the TAM was implemented to evaluate the perceived usefulness and ease of use of telematics systems in the road transport industry in 2020 and 2021. The model estimated in 2021 was extended by adding latent variables observed in 2020 to capture the impact of the COVID-19 effect. The model's structure is presented in Fig. 1.

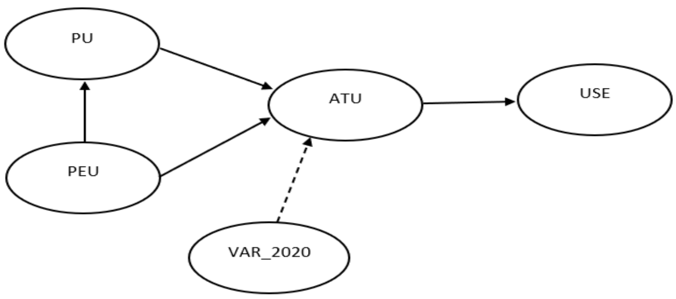

Fig. 1. The TAM's structure

Note: PU – perceived utility, PEU – perceived ease of use, ATU – attitude towards using, VAR_2020 – latent variables (PU, PEU, and ATU) observed in 2020, USE – actual use

In the TAM, all variables except USE are latent. They are constructed from several observed variables to create constructs corresponding to perceived usefulness, perceived ease of use, and attitudes toward use. The research questions were formulated as below:

1. Are telematics technology solutions perceived as beneficial by road transport managers?
2. Are there any difficulties related to the technical aspect of telematics technologies' use?
3. What motivates road transport managers to use telematics technologies?

4. What changes took place between 2020 and 2021 in applying telematics technology solutions in road transport?
5. Which individual factors can serve as incentives for the broader application of telematics technology solutions in road transport?

The answers to questions 1-3 are based on confirmatory factor analysis, while question 4 is answered based on the estimated TAM. Answering the last question requires simulations prepared on the estimated TAM.

3. DATA

The selection of transport companies located in Poland is related to the vital position of the transport industry in the European market. Longitudinal data gathered in 2020 and 2021 were used. At both time points, the questionnaire was directed to 500 managers of transport enterprises registered in Poland performing road transport activities throughout Europe.

A sample of enterprises was selected from the ZMPD (Association of International Road Carriers in Poland) database and the regional associations of road carriers. As a result, 3,750 enterprises were identified from the ZMPD database, and 750 were identified from the provincial associations' databases. Finally, the sample from which the companies were drawn comprised 4,500 enterprises. The study's authors prepared the questionnaire, but the survey was outsourced to a research company that used the computer assisted telephone interviewing method. The average duration of the interview was 20.23 min. In 2020 and 2021, 500 enterprises answered the questionnaire, but 323 agreed to respond twice, yielding a proportion of 64.6%. All surveyed enterprises are experienced in using telematic systems. Namely, 47.7% of respondents have used them for more than 10 years, 33.4% have used them for five to ten years, and 18.9% have used them for one year to three years. However, the scope of using information from the telematics technology was gradually extended, starting with truck tracking to the more complex monitoring of the vehicle and driver. The COVID-19 pandemic increased the broad application of telematics technology in transport enterprises.

Therefore, a sample of 323 managers was used in the empirical study, allowing longitudinal analyses to be conducted. Based on repeated measurements among enterprises, such research focuses on understanding the nature of change in telematics technology perceptiveness over time [15]. The structure of selected enterprises corresponds to the actual structure of road transport enterprises in Poland (i.e., 6.6% are microenterprises, 49.5% are small enterprises, 37.7% are medium-sized enterprises, and 6.2% are large enterprises, which have more than 250 personnel). Concerning the number of drivers, the proportions are as follows: 1-9 – 21.7%; 10-49 – 53.0%; 50-249 – 23.6%, over 250 – 1.7%.

Below, we compare the respondents' answers to the questions corresponding to the TAM constructs. They were ordered logically on a seven-point Likert scale. The Likert scale comprises five (or more) points, allowing the individual to express how much they agree or disagree with a particular statement. The variables' names are explained subsequently in Tables 1-3. It is worth noting that the data were checked and cross-validated before being used in the empirical analysis.

1. Perceived ease of use (PEU) – applying a new technological solution is easy, understandable, and intuitive for the user. Table 1 shows the comparison of respective response shares in 2020 and 2021. The responses of the respondents changed between 2020 and 2021. These changes consisted of a significantly lower proportion of 6 (agree) and 7 (strongly agree) responses on the Likert scale and an increased proportion of 5 (somewhat agree) responses. The ratio of responses between 1 and 4 on the Likert scale was low and, therefore, omitted from the Tables.
2. Perceived utility (PU) – the level of users' conviction that by using telematics technology, they improve the results of their work or increase their efficiency and consequently improve the operational management level in the enterprise. The comparison of responses in 2020 and 2021 is presented in Table 2.
3. Motivation for telematics systems in transport companies (ATU) is crucial for their actual use. Table 3 compares the results obtained in 2020 and 2021.

Table 1

Percentage of answers obtained for the variables (x1-x5) forming "perceived ease of use" – Comparison of survey results in 2020 and 2021

PEU	Answer 2020 [%]				Answer 2021 [%]			
Variable description	5	6	7	6+7	5	6	7	6+7
x1: retracing the routes for all orders executed	10.0	54.2	33.8	88.0	24.8	26.0	22.3	48.3
x2: analysis of the vehicle's timely arrival for loading and unloading	11.2	52.4	34.2	86.6	20.4	29.4	21.4	50.8
x3: analysis of delays and their reporting to the contracting party	10.6	52.8	34.8	87.6	21.4	31.6	20.1	51.7
x4: analysis of the driver's working time in the last 24 hours, seven days, and 14 days	10.2	53.4	34.2	87.6	18.0	35.0	20.7	55.7
x5: analysis of the vehicle's fuel consumption	7.8	46.8	42.2	89.0	18.0	29.7	23.2	52.9

Note: In Tables 1-3, responses referring to 5, 6, and 7 on the 7-point Likert scale are presented. The entire scale is used in the study, but the share of responses indicating values 1-4 is very low, particularly in 2020. In 2020, the percentage of responses ranging from 1-4 was around 2.5%, while in 2021, it was about 25-30%

Table 2

Percentage of answers obtained for the variables (x6-x10) forming "perceived usefulness" – Comparison of 2020 and 2021 survey results

PU	Answer 2020 [%]				Answer 2021 [%]			
Variable description	5	6	7	6+7	5	6	7	6+7
x6: impact on the effectiveness and efficiency of the entire company	11.2	72.7	13.4	86.1	26.4	33.2	20.5	53.7
x7: improves the control and analysis of the planned route travel by the vehicle	13.0	62.7	22.7	85.4	25.2	28.0	23.0	51.0
x8: improves the timeliness of tasks execution	12.7	65.5	19.6	85.1	19.3	33.9	21.7	55.6
x9: increases the contracting parties' trust in the company	12.4	64.3	21.7	86.0	23.3	29.8	22.0	51.8
x10: improves the orders' profitability	10.6	69.3	18.6	87.9	20.8	32.0	24.8	56.8

Table 3

Percentage of answers obtained for the variables (x11-x13) forming the "attitude towards use" – Comparison of survey results obtained in 2020 and 2021

ATU	Answer 2020 [%]				Answer 2021 [%]			
Variable description	5	6	7	6+7	5	6	7	6+7
x11: employees' motivation to use the telematics system in your company	14.3	68.3	15.8	84.1	26.4	30.7	13.4	44.1
x12: the importance of knowledge acquired from the telematics system for the company's operation in the transport market	12.1	71.4	14.9	86.3	23.6	30.7	15.8	46.5
x13: the decision to use a telematics system – autonomous or imposed by contractors	9.6	73.3	16.5	89.8	17.7	29.5	11.8	41.3

By analyzing the data in Table 3, one can observe a significant difference between the 2020 and 2021 surveys. The first difference is in the share of answers with the highest level of acceptance (6 and 7 on the Likert scale). The evaluation of managers' motivation was much more moderate in 2021 than in 2020. There was a significant increase in the number of 5 (somewhat agree) responses compared to 6 (agree) and 7 (strongly agree) responses. For variable x13, a difference was observed for responses between 1 and 4, as 40.8% of respondents selected responses in this range.

4. Use (USE) – The question was related to the actual use of the telematics system in the enterprise, measured on a 7-point Likert scale, where 1 means "no use" and 7 means "continuous use." The majority of respondents (66.6%) stated that they use the telematics system very extensively (i.e., they use most of the system's functions), choosing answers 5, 6, and 7. For comparison, in the 2020 survey, 72.8% of respondents selected answer 6, and 11.4% chose to answer 7.

The data from the survey questionnaire for 2020 and 2021 show different distributions of responses to questions describing the variables of the TAM. For all variables, the average grade assigned by users was significantly higher in 2020 than in 2021. The more intensive exploitation of the telematics system increased users' experience and allowed the perception of some of its functionalities as "standard" instead of "desired." The users might have noticed some system limitations. In 2020 the users better rated the telematics system's ease of use, utility, motivation, and actual use. Furthermore, the notes assigned to each aspect of using telematics technology were more diversified in 2021 than in 2020. The standard deviations in 2021 were twice as high as those in 2020.

4. EMPIRICAL RESULTS

4.1. Measurement constructs and scale reliability

The latent variables included in the TAM (i.e., PU, PEU, and ATU) were verified for the assessment criteria. The reliability (AC), average variance (AVE), and composite reliability (CR) were computed and are presented in Table 4.

Table 4

Summary of latent variables and reliability statistics

Variable name	Variables	Cronbach's alpha statistic (AC)	AVE	Composite reliability (CR)
PEU	x_1, x_2, x_3, x_4, x_5,	0.948	0.785	0.948
PU	x_6, x_7, x_8, x_9, x_{10}	0.942	0.764	0.942
ATU	x_{11}, x_{12}, x_{13}	0.877	0.681	0.864
USE	x_{14}	-	-	-
PEU_2020	z_1,z_2,z_3,z_4,z_5	0.846	0.525	0.847
PU_2020	z_6,z_7,z_8,z_9,z_{10}	0.821	0.502	0.834
ATU_2020	z_{11}, z_{12}, z_{13}	0.527	0.343	0.591
USE_2020	z_{14}	-	-	-

Note: x_i refers to variables observed in 2021, while z_i refers to those surveyed in 2020. Variables defined based on 2020 data are completed by the year in their names

The values of Cronbach's alpha (CA) statistics for all latent variables related to 2021 are much higher than the recommended value of 0.7, which indicates excellent scale reliability [16]. The same was found for to composite reliability (CR), for which values are higher than the recommended 0.7 level. Furthermore, the average variance extracted (AVE) values are higher than 0.5, thus fulfilling the Fornell-Larcker criterion [17]. These measures confirm an excellent reliability scale for each latent variable. The only doubts were related to the reliability statistics values for the attitude toward using in 2020 (ATU_2020) variable. It was included in the model for comparison reasons only. We expect that the first phase of the pandemic data collected in 2020 might be related to systematic and random actions. The increased impact of randomness resulted from many stress factors that enterprises faced.

4.2. Estimated TAMs

Structural Equation Modelling (SEM) was used to determine the relationships between perceived usefulness, perceived ease of use, attitude toward using, and actual system use according to the TAM. The research was based on 322 companies questioned in both 2020 and 2021. The models allowed an analysis of cause-and-effect relationships between the latent variables, which could not be measured directly [18-20]. The essential model is the extended TAM based on 2020 and 2021 observations. For comparison, standard TAMs were estimated separately for 2020 and 2021.
The models' parameters were estimated using the maximum likelihood (ML) method available in SPSS AMOS v.16 packages. A significance level of 0.05 was assumed. The final estimation results are summarized in Table 5. Table 6 presents the results for the external part of the SEM model (confirmatory factor analysis).

Table 5

Estimated TAMs

Relationship	Coefficient	SE	p-value
TAM 2020			
PEU ⇨ PU	0.5301	0.0640	0.0001
PEU ⇨ ATU	-0.0642	0.1090	0.4643
PU ⇨ ATU	0.2510	0.1131	0.0150
ATU ⇨ USE	0.7971	0.0322	0.0000
CMIN/DF = 2.328 IFI = 0.934 RMSEA = 0.064 AIC = 262.254 BCC = 266.665			
TAM 2021			
PEU ⇨ PU	0.9301	0.0201	0.0000
PEU ⇨ ATU	0.5322	0.1570	0.0000
PU ⇨ ATU	0.4210	0.1581	0.0000
ATU ⇨ USE	0.9680	0.0032	0.0000
CMIN/DF = 2.835 IFI = 0.972 RMSEA = 0.076 AIC = 299.770 BCC = 304.182			
Extended TAM 2020 and 2021			
PEU ⇨ PU	0.9301	0.0201	0.0000
PEU ⇨ ATU	0.5452	0.1640	0.0000
PU ⇨ ATU	0.4081	0.1662	0.0000
ATU ⇨ USE	0.9680	0.0031	0.0000
PU_2020 ⇨ ATU	0.0711	0.0330	0.0171
CMIN/DF = 2.057 IFI = 0.971 RMSEA = 0.057 AIC = 426.476 BCC = 434.583			

Note: minimum discrepancy (CMIN/DF) [18], incremental fit index (IFI) [18], root mean square error of approximation (RMSEA) [18], Akaike Information Criterion (AIC) [21], Browne-Cudeck Criterion (BCC) [22]

The model based on 2021 data confirms the significant causal relationships between PEU, PU, and ATU. Furthermore, the causal relations of PU ⇨ ATU and ATU ⇨ USE were significant. These results mean that the less complicated the system (PEU) is, the higher its perceived usefulness and attitude toward use. As perceived usefulness increases, the motivation to use a system (ATU) also increases, which contributes to the broader use of telematics systems (USE). The values of standardized estimates in standard, and extended models are very close and positive, in line with the TAM assumptions.

Based on the extended TAM, the perceived usefulness of telematics technology observed a year earlier (PU_2020) has a slight but significant impact on the current attitude toward using these systems. This outcome means that the more useful telematics technology has been for the users, the greater their current motivation to use them. We also checked PEU_2020, but the relationship was not satisfactory.

The associations observed in 2020 (standard TAM 2020) revealed that most parameter estimates are statistically significant, as in 2021. The only difference is in the relationship between PEU and ATU. In 2020, the impact of perceived ease of use on attitude towards using was insignificant. The explanation is that ease of use becomes more meaningful for users if they systematically work with telematics technology, as was the case during the pandemic. At the beginning of the pandemic, enterprises started to use telematics technology systems more widely than before. Gaining more experience fosters users' familiarity with new technology and gives them more reliable results. Given that most road transport enterprises belong to the SME sector, their resources are limited, and their employees must be engaged in various activities. Furthermore, the negative and insignificant value of this parameter's estimate should be interpreted with care because the attitude toward using in 2020 was not entirely reliable according to the reliability measures.

Table 6

Estimated TAM external models (confirmatory factor analysis)

Relationship	Coefficient	SE	p-value
x_1 ⇨ PEU	0.8681	0.0150	0.0000
x_2 ⇨ PEU	0.8861	0.0142	0.0000
x_3 ⇨ PEU	0.9150	0.0121	0.0001
x_4 ⇨ PEU	0.8812	0.0181	0.0000
x_5 ⇨ PEU	0.8791	0.0212	
x_6 ⇨ PU	0.8600	0.0201	0.0000
x_7 ⇨ PU	0.8420	0.0201	0.0001
x_8 ⇨ PU	0.8680	0,0161	0.0000
x_9 ⇨ PU	0.9061	0.0122	0.0001
x_{10} ⇨ PU	0.8942	0.0151	
x_{11} ⇨ ATU	0.8050	0.0311	
x_{12} ⇨ ATU	0.9032	0,0160	0.0000
x_{13} ⇨ ATU	0.7611	0.0311	0.0000
z_6 ⇨ PU_2020	0.6352	0.0542	0.0000
z_7 ⇨ PU_2020	0.6861	0.0492	0.0000
z_8 ⇨ PU_2020	0.6852	0.0432	0.0001
z_9 ⇨ PU_2020	0.7431	0.0401	0.0000
z_{10} ⇨ PU_2020	0.7111	0.0470	

Note: x_i refers to variables observed in 2021, while z_i refers to those surveyed in 2020. Variables defined based on 2020 data are completed by the year in their names

Goodness-of-fit measures, such as RMSEA and IFI, were evaluated. The IFI values are almost identical in both models, but the RMSEA and CMIN/DF statistics are better for the extended model. The IFI values higher than 0.95 and RMSEA less than 0.08 evidence a perfect adaptation of the models to the data [23].

4.3. Robustness check

Bootstrapping was employed to re-estimate the model parameters with the ML (maximum likelihood) estimator. The procedure was used for the model estimated based on the total sample. The bootstrap based on 5,000 iterations helped calculate the estimation bias and standard errors and determine the bias-corrected 95% confidence intervals [24]. Table 7 summarizes the results for internal TAMs.

The confidence intervals corrected with the bias confirm the significance of the parameter estimates with the maximum likelihood method. Hence, the ML-estimated models verified with bootstrapping allow reliable inferences to be made based on the models.

5. SIMULATIONS AND PREDICTIONS

The research results provide valuable feedback to digital platform providers beyond cognitive purposes. For this reason, predictions and simulations were handled. The results show which aspects of the telematics technology system's functionalities are most important for the user and how they influence users' motivation and the system's actual usage.

Factor score weights were used to predict latent variables such as ATU, USE, PEU, and PU [25]. These weights allow the estimation of the values of the latent variables using the observed weights as a weighted sum. Thus, the score weights show how the latent variable will change if the observed variable increases by one point on the Likert scale. The factor score weights for the extended TAM model are presented in Figure 2. The figure was restricted for variables x1–x10 and z6–z10, which describe perceived ease of use and perceived usefulness in 2021 and 2020, respectively. The factor score weights are assigned to attitude towards using (ATU) and actual use of the system (USE). The other variables are omitted because of their presence in ATU and USE.

Table 7

Results of TAM estimations with bootstrapping

Relationship	Coefficient	Bias	SE bias	Lower limit	Upper limit	p-value
TAM 2020						
PEU ⇨ PU	0.5301	-0.0041	0.0010	0.3952	0.6450	0.0000
PEU ⇨ TU	-0.0641	-0.0032	0.0022	-0.2782	0.1440	0.5832
PU ⇨ TU	0.2512	0.0060	0.0021	0.0221	0.4632	0.0311
ATU ⇨ USE	0.7970	-0.0052	0.0002	0.7240	0.8481	0.0000
TAM 2021						
PEU ⇨ PU	0.9300	-0.0011	0.0000	0.8841	0.9640	0.0010
PEU ⇨ TU	0.5321	-0.0161	0.0021	0.2872	0.9140	0.0001
PU ⇨ TU	0.4212	-0.0162	0.0020	0.0362	0.6661	0.0320
ATU ⇨ USE	0.9680	0.0000	0.0001	0.9630	0.9731	0.0002
Extended TAM 2020 and 2021						
PEU ⇨ PU	0.9301	-0.0010	0.0001	0.8840	0.9642	0.0011
PEU ⇨ TU	0.5450	0.0200	0.0021	0.2892	0.9351	0.0001
PU ⇨ TU	0.4081	-0.0201	0.0021	0.0081	0.6601	0.0451
ATU ⇨ USE	0.9682	0.0032	0.0000	0.9632	0.9732	0.0001
PU_2020 ⇨ TU	0.0711	0.0332	0.0000	0.0071	0.1371	0.0292

For ATU and USE, variables x3, x9, and x10 are the most meaningful. This means that the values of ATU and USE depend heavily on the ease of analysis of delays and their reporting to the contracting party in the telematics technology system (x3), as well as on how the telematics technology influences the contracting parties' trust in the company (x9) and orders' profitability (x10). Telematics technology providers should consider these factors to make the systems more user-friendly.

In addition to finding essential variables, some simulations were carried out. The framework of the simulations is as follows. Two new variables were created for each observed variable: x1–x10 and z6–z10. The values of the first variable are one point lower than those of the original variable. The values of the second variable are one point higher than those of the original variable. The values were restricted to a 1-7 scale, as was the case in the original dataset. Next, 30 extended TAMs related to the defined variables were estimated. Only one variable from the original model was changed by the new one in each estimated model. The simulation aimed to determine how sensitive the parameters in the TAM are to changes in the telematics functionality. Figure 3 shows the minimum and maximum values of parameter estimates for PEU ⇨ ATU and PU ⇨ ATU based on the calculation of three models: the original model, a model with the corresponding variable lowered by one point on the Likert scale, and a model with the corresponding variable increased by one point. The higher the column in the figure, the greater the difference between the minimum and maximum values of the parameter estimates. Note that, in cases for which the maximum value of analyzed parameters was the same as it was for the original model (0.545 for PEU⇨ATU and 0.408 for PU⇨ATU), the increased values of the corresponding observed variable caused a weaker relation from perceived ease of use or perceived usefulness to attitude toward using.

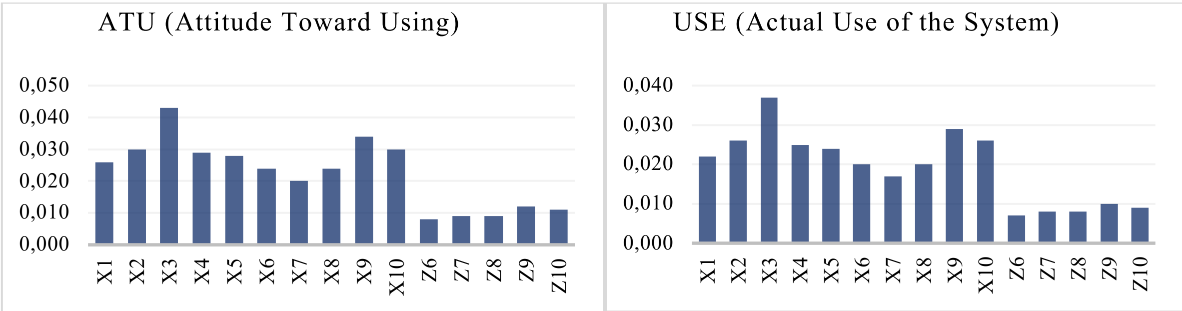

Fig. 2. Factor score weights between individual observed variables and ATU and USE
Note: x_i refers to variables observed in 2021, while z_i refers to those surveyed in 2020. Variables defined based on 2020 data are completed by the year in their names

Based on the results, the relation between PEU and ATU is the most sensitive to changes in ease of analysis of the vehicle's fuel consumption in the telematics technology system (x5), effectiveness and efficiency of the entire company (x6), contracting parties' trust in the company (x9), and orders' profitability (x10) obtained by the telematics technology system. For the relation between PU and ATU, the most influential variables are x6, x9, x10, and x3 (ease of analysis of delays and their reporting to the contracting party). The increased role of the telematics technology in contracting parties' trust in the company (x9) and orders' profitability (x10) causes a more substantial relation between PEU and ATU and a weaker influence PU on ATU. By changing the perceived ease of use and perceived usefulness of telematics in these aspects, the systems' providers can influence how these latent variables generate motivation for users to use their systems.

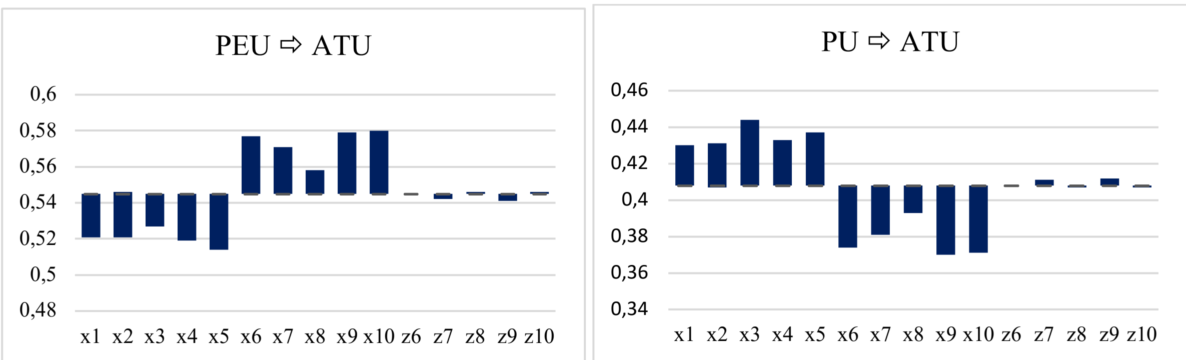

Fig. 3. Minimum and maximum values of PEU ⇨ ATU and PU ⇨ ATU parameters
Note: x_i refers to variables observed in 2021, while z_i refers to those surveyed in 2020. Variables defined based on 2020 data are completed by the year in their names

6. DISCUSSION

Telematics systems play an increasingly important role in road transport management, as the data captured can be further integrated with other operational systems belonging to the TMS. It is essential to identify and separate the external factors that determine a road transport company's functioning from those related to the direct impact of telematics on its functioning. Heinbach et al. [26] analyzed 74 websites of telematics system manufacturers and conducted structured interviews with 42 practitioners employed by five companies providing digital services to TSL operators. They found that integrating telematics systems with other TMS, driver, and vehicle position monitoring methods is essential for the correct design of systems used by supervisory personnel. Other functions of the systems, such as monitoring vehicle performance indicators, data records, reports, transport safety, and the level of logistics support, were of little importance.

The current study uncovered that the COVID-19 pandemic significantly impacted the use of telematics systems in road transport companies. Data collected in two waves of observations enabled direct comparisons of individual variables and latent factors defined in the TAM. Above all, the average value of all responses in 2021 decreased compared to the average value related to 2020 responses. In 2020, companies increased their telematics applications, driven by the need to send documents electronically due to the pandemic and optimism about the future. In the following months, this action became standard for companies. A repeat of the survey in 2021 confirmed that the prolonged use of IT does not have an increased effect on its perceived usefulness, motivation, or actual use. Ease of use, which increases with user experience and user support by the company providing the system, is slightly different.

It is noteworthy that, in 2021, the averages of all responses on the 7-point Likert scale were higher than 5, except for variable x13 (4.87). In 2021, however, the variation among companies increased in all variables. Thus, it can be concluded that telematic systems are helpful for road transport companies.

The results confirmed that the TAM is an appropriate tool for evaluating the acceptance of telematics technology in road transport enterprises. All specified relationships are statistically significant and reasonable. In the standard model for 2021, the highest coefficients are for the following relationships: PEU ⇨ PU and ATU ⇨ USE. The exact relations are the strongest in the extended model, but another link is essential (i.e., PU_2020 ⇨ ATU). This means that if perceived utility in 2020 increases by one point on the Likert scale, attitude towards using increases by 0.071, confirming that experience is essential to the motivation to use telematics. The bootstrap procedure demonstrates the robustness of the results. The TAM estimates based on data collected in 2020 are unreliable, as the responses were too optimistic since managers overestimated the application of telematics technology in their enterprises. The simulations based on the extended TAM revealed which individual variables are primarily responsible for increased perceived ease of use and perceived usefulness, which are causally related to attitude towards use and actual use. Therefore, the model was advantageous from both a cognitive and practical perspective. It is helpful for telematics system producers and distributors.

When applying the TAM model for telematics that supports road freight management, other solutions strongly correlated with strategic and operational road transport management must also be kept in mind. Although customers use transport management solutions, they are increasingly turning to solutions based on digital platforms, most of which are cloud-based. Various digital platforms (DPs) primarily support road freight transport management processes. As Heinbach et al. [27] pointed out, in a data-driven world, the ubiquity of DPs enables product and service transactions between the demand and supply side (e.g., in the context of service price matching, suggestions for transported products, or in terms of relevant recommendations from transaction partners). DPs apply, for example, to streamlining order flow and supporting operational decision-making.

On the other hand, platforms are used for strategic activities, which are data warehouses that, once processed, can be used for analysis and decision-making. As mentioned, the range of data extracted from digital platforms is diverse, ranging from research related to vehicle production to data-mining services based on telematics in fleet management.

The study's limitations are related to the number of enterprises that agreed to participate in the research. Of 500 enterprises, 323 responded twice in two waves, providing a satisfactory ratio overall, particularly for the model estimation. However, an extended and more diversified sample of respondents would enable more comparisons between enterprises.

7. CONCLUSIONS

The present study assessed the acceptance of telematics technology in the road transport industry. Though very useful for truck tracking, telematics systems offer much more information desired in the transport business's operational management. Longitudinal data collected from transport enterprises in 2020 and 2021 enabled an assessment of the impact of the COVID-19 pandemic on the telematics system application. All estimated relationships were positive and significant. The latent variable constructs are highly reliable. Model validation using the bootstrap procedure confirmed the results of the estimation. Based on the factor score loadings, it became apparent that latent variables such as ATU and USE mainly depended on ease of analysis of delays and their reporting to the contracting party in the telematics technology system and on how the telematics system influences the contracting parties' trust in the company's and orders' profitability. Simulations revealed which variables have the most significant impact on ATU and USE. Telematics technology providers should consider these elements to make the systems more reliable, user-friendly, and adjusted to users' actual needs. The findings confirmed that the telematics technology was both functional and straightforward.

Telematics systems are not new, but their application has often been limited to truck tracking during transport activities. However, they offer much more analytical information necessary for enterprise management. Since the pandemic began, many documents have been sent electronically using integrated TMSs. Therefore, in 2020, managers were very optimistic about the application of telematics technology in the transport sector. By gaining more experience and collecting more data, they increased their knowledge and were able to justify the system's usefulness in everyday practice. Thus, data collected in 2021 are more reliable than data collected in 2020 and confirm a positive change in managers' perceptions of telematics systems that can be generalized.

Further research is worth conducting. First, future studies should compare the findings based on the experience of enterprises in Poland to findings in other countries and regional markets in Europe and beyond. The additional stream of studies can compare the quality of telematics services employed by transport operators to the broad range of digital services offered by platform providers, such as the estimated arrival time and cost analysis.

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