Detection and Analysis of Barriers to Truck Driver Performance for Safe Transportation

Cansu Akçicek
Research Assistant in Graduate School
Yaşar University
Izmir, Turkey
cansu.akcicek@yasar.edu.tr

Yucel Ozturkoglu
Full Professor of Logistics Management
Faculty of Business
Yaşar University
Izmir, Turkey
yucel.ozturkoglu@yasar.edu.tr

Omer Ozturkoglu
Assoc. Professor in Business Administration
Faculty of Business
Yaşar University
Izmir, Turkey
omer.ozturkoglu@yasar.edu.tr
and
Department of Engineering, Birmingham City University, Birmingham, UK
omer.ozturkoglu@bcu.ac.uk

Abstract

The increased e-commerce volume, especially with the pandemic, has shown us that the supply chain should never be broken. Transportation, which is the most crucial element that connects the rings along the chain, has become more critical. In the face of this situation, almost the whole world has faced the problem of truck driver shortage that has never been mentioned before. The accident caused by the truck drivers, which we already have problems with in terms of numbers, causes enormous losses in the chain such as high cost, time, and stock out. Therefore, the primary purpose of this study is to identify the various barriers that are critical to the success of truck drivers in providing safe transportation and to determine the weights and relative importance of these barriers. To find answers to these questions, firstly, a detailed literature review is conducted to identify the barriers and challenges. Later, to find the effects of these barriers within themselves, the Best-worst method (BWM) is used, which is one of the decision-making models. With this method, the importance order of barriers is determined from a holistic perspective. Based on the results use of mobile phones is the most critical barrier among the sub-barriers. If it is necessary to sort among all barriers; the age of the driver, experience of the driver and eating & drinking in the car follow looking at external objects, respectively. Surprisingly, the aggressive driver behaviors barrier came in at the bottom of the overall barrier ranking. Based on these results, this study gives the reader a comprehensive insight into how detected barriers affect truck driver performance. Therefore, this framework is a roadmap that is designed with a holistic view to guide manufacturers, logistics parties, and even policy and decision-makers.

Keywords
Logistics, Best-worst method, Truck drivers, Decision-making models, Transportation

1. Introduction

Logistics and production are integral parts of a system, and the supply chain is one of the essential components in ensuring this integrity. Managing the supply chain well diminishes a company's expenses, increases profits, and also provides a balance between logistics and manufacturing activities. After the development of e-commerce since 2014, logistics and supply chain activities have gained significant importance. With the developing technology, consumers have the opportunity to examine the products they need at any time and to save time by making product and brand comparisons in a short time, which encourages consumers to shop from e-commerce sites. Ensuring that products are delivered to the customer on time and appropriately is a critical action in the supply chain. E-commerce retail sales have grown rapidly since 2014, with worldwide retail e-commerce sales reaching $4.28 trillion in 2020 (Chevalier 2021). The pandemic that emerged towards the end of 2019 and to which the whole world was exposed also has a share in this rapid increase. Especially in 2020, most governments implemented full or partial lockdowns that negatively affected retailers and leads closures. While some retailers have found solutions with e-commerce, others have had to exit the market. With the changing consumer behavior due to long-term quarantines, a new market has emerged for retailers engaged in e-commerce, and sales have begun to increase. However, problems such as the interruption of international trade as a result of the closure of the country's borders and the labor shortage due to lockdowns cause some disruptions in the supply, transportation, and production stages (Chowdhury et al. 2021). For instance, raw material supply in production processes has become a major crisis for some sectors, as was the case of the chip shortage crisis experienced by automobile manufacturers during the pandemic period. As Wu et al. (2021) stated, important automobile manufacturers such as Volkswagen and Toyota have had to suspend or close their production lines in some countries. Considering such situations, logistics transportation and supply chain have become important.

In addition to the problems experienced in supply and manufacturing during the pandemic period, some problems have arisen in transportation as well. First of all, as the number of healthy drivers decreased due to the increasing rate of spread of the epidemic, it became difficult to find substitutes for the truck drivers who had the disease. Besides, although the regulation sets a driving limit of 11 hours after 10 consecutive hours of leave and a maximum of 60 hours of driving in a week with consecutive working days (FMCSA 2020), drivers may not comply with the rules in order to complete their transportation task. Moreover, while drivers are required to take a 30-minute break when they drive for an 8-hour period, they continue to drive without taking a break in order to deliver the shipment on time. Unfortunately, in such cases, the distraction of drivers who are exposed to long working hours due to non-compliance with legal regulations can sometimes cause traffic accidents.

The increasing importance of the supply chain is emphasized not only by new developments such as e-commerce or the emergence of situations such as pandemics but also by unexpected crises such as truck driver shortages that happen in the United Kingdom after Brexit. Grozoubinski (2018) emphasizes that since the licenses of companies with Community Licenses issued by the UK after Brexit are no longer accepted in the European Union, the truck drivers of these companies cannot provide transportation to European Union countries. While this problem causes unemployed truck drivers who cannot work because they do not have a valid driver's license in the EU, the truck driver shortage across Europe also causes significant problems in the supply chain of companies. It is predicted that truck driver issues will continue to be a problem in logistics activities, as in the examples of Brexit and pandemic crisis. In previous studies, the scheduling of truck drivers for shipment planning of the companies is most studied. However, to the best of authors' knowledge, in literature, a big gap exists due to the lack of studies on reasons and mitigation strategies for truck driver distractions. Therefore, it is considered as the motivation of this study that there should be more studies in the literature that include the precautions to be taken for truck drivers to have secured transportation. To the best of our knowledge, this is the first study that focused on identifying barriers and challenges to truck driver distraction, both theoretically and empirically. Therefore, the main purpose of this study is to identify the various barriers that are critical to the success of truck drivers in providing safe transportation and to determine the weights and relative importance of these barriers. Therefore, this study gives the reader a comprehensive insight into what are the barriers for truck drivers to increase their success in providing safe transportation.

To find answers to these questions, firstly, a detailed literature review is conducted to identify the barriers and challenges. Later, to find the effects of these barriers within themselves, the Best-worst method (BWM) is used, which is one of the decision-making models. With this method, the importance order of barriers is determined from a holistic perspective.

The remainder of the article is structured as begin with a literature review related to truck drivers' distractions in Section 2. The methodology and data collection are described in Sections 3 and 4, respectively. Numerical results and discussion are presented in Section 5, and the final section of the article summarizes and concludes the study.

2. Literature Review

As mentioned in the previous section, the vital role of truck drivers in logistics and supply chain activities and the lack of studies in literature related to truck drivers' distraction are the motivation of this paper. Considering the factors that cause accidents, distraction and inattention have an important role (Regan et al. 2011; Klauer et al. 2006; Olson et al. 2009). Until now, driver distraction and inattention problems have been addressed in different studies. These two terms have different meanings, however, they can be confused as both are close in meaning. Lee et al. (2008) state that distraction is considered a subset of inattention and as basic meaning that diversion of the driver's attention from the driving activity. In another sense, driver distraction means paying attention to other tasks unrelated to driving, thus resulting in imminent crashes or serious crashes (Regan et al. 2011; Hedlund et al. 2005). On the other hand, driver inattention occurs when the driver chooses to divert attention for a non-coercive reason (Regan et al. 2011; Treat 1980). Since the problems of driver distraction and its effects are examined rather than driver inattention in the literature, this paper also focuses on studies on this subject.

Types of driver distraction are examined in two categories as inside of the vehicle and outside of the vehicle in the study of Regan et al. (2008). They state that advertising billboards are examples of outside vehicle factors that might distract attention while driving. When an advertisement is seen on the billboard that may attract the attention of the driver, the driver may not be able to continue the driving action by turning the attention in that direction. Billboards can pose a risk to drivers when they draw their gaze longer than 0.75 seconds, as this is considered the minimum detection-response time required to react to an unexpected braking premise vehicle (Cunningham and Regan 2018; Smiley et al. 2004). Also, looking at external objects, buildings, and previous accidents distract the driver. Other external sources of distraction are the age and experience of the driver. In fact, although the increase in the age of the driver means an increase in experience, it is seen that it may affects the driving vision and reflexes adversely (NHTSA, 2021).

Bayly et al. (2008) state that driver distractions in the vehicle can be caused by technology-related and non-technology-related reasons. Drivers in a hurry to reach a place may engage in activities that should not usually be done while driving, and these actions are expressed as non-technology related in-vehicle distractions. For instance, if the driver does not have time for breakfast or lunch, eating and drinking in the car cause distraction. Especially at this time, dropping things into the car and trying to reach the dropped object reduces the driver's attention to the road, leading to possible accidents. Furthermore, the presence of passengers in the vehicle may negatively affect the driver's attention due to the driver's focus on conversation (Zhang et al. 2019). In light of past studies, Zhang et al. (2019) examine the effect of the presence of passengers on young driver distraction and behavior, taking into account the gender of the passenger and driver. Indeed, the in-vehicle factors that cause drivers to be distracted are not limited to this.

The use of mobile phones as technology-related in-vehicle distractions is the most cited issue. With the development of technology, it has become inevitable to increase the accidents caused by the use of mobile phones. When drivers use a mobile phone while driving, their eyes are off the road, and this is called visual distraction, their minds are off the road, and this is a cognitive distraction, and finally, their hands leave the steering wheel because they are using a phone, which is called physical distraction (World Health Organization, 2011). It is aimed to reduce accidents by increasing the use of hands-free phones instead of hand-held phones. In addition, automobile manufacturers contribute to reducing the use of hand-held phones by producing alternative solutions thanks to Bluetooth-connected technological interior equipment. While this technology is helpful for answering calls, drivers' texting tendencies still remain a major factor for distraction. Ortiz et al. (2018) state that due to the rapid increase in the use of smartphones, accessing the internet, using social media applications, or checking e-mail and messaging poses a risk to the driver's attention on the road. Besides, the development and widespread use of In-Vehicle Information Systems (IVIS) bring several benefits in terms of productivity, however, it endangers traffic safety (Donmez et al. 2003). Technological systems such as satellite navigation devices, Bluetooth, audio, and touch screen in vehicles are also examples of in-vehicle technological distractions.

Driver distraction can also happen to drivers using transportation vehicles such as trucks. However, few studies have examined the prevalence of distracted driving and associated accident risk among large truck drivers (Claveria et al. 2019; Hickman and Hanowski 2012; Olson et al. 2009). The relationship between mobile phone usage and large truck accidents and the factors in truck drivers' phone usage while driving are examined with the data collected through a survey in the study of Claveria et al. (2019). Stavrinos et al. (2016) also examine the effects of cell phone usage and texting on the driving performance of truck drivers by using a driver simulator. In addition, some products such as satellite tracking, navigation, and wireless telephone are used in trucks for tracking vehicles and communicating with dispatchers. A research program from NHTSA, U.S. Department of Transportation, National Highway Traffic Safety Administration, presents workload assessment methods to determine the safety implications of using in-vehicle technologies while driving (Ranney et al. 2001). Another point of view that causes truck driver distraction is driver fatigue caused by long hours of work and lack of sleep (Horberry et al. 2021). Bunn et al. (2005) conducted a study that analyzed both sleepiness and fatigue of truck drivers as accident factors. In order to reduce driver fatigue, daily and weekly limits on working hours are regulated in countries. However, non-compliance with these regulations, especially due to truck drivers' efforts to deliver the shipment on time, driver fatigue is still considered one of the major causes of accidents. Young (2008) estimates that 55% of all known sources of distraction are preventable, which an indication that countermeasures can be developed is (Regan and Hallett 2011).

There are several studies to research mitigation strategies for driver distraction in literature. In the study of Donmez et al. (2003) mitigation strategies are separated into which driving-related or non-driving-related categories with three different levels of automation, and it has been investigated whether driver distraction mitigation strategies reduce driver distraction (Donmez et al. 2006). Utilizing the IVIS feature to prevent an accident during distraction has revealed the warning as a mitigation strategy of distraction. The success of collision warning systems depends on how well the algorithm is adapted to the capabilities and preferences of the driver. (Lee et al. 2004). In general, previous studies have used linear and logistic modeling approaches for mitigation strategies, while recent studies have been working on trending approaches such as machine learning to implement in-vehicle technologies (e.g., McDonald et al. 2020; Masood et al. 2020; Schwarz et al., 2016). The use of monitoring and warning systems has increased with the development of the driver monitoring system (DMS), which gives an audible warning when it detects a state of inattention (Ferreira et al. 2019). These mitigation strategies can also be beneficial for long haul vehicles. Monitoring, detection and mitigation of distractions are of great importance for the prevention of traffic accidents and the health of truck drivers with long working hours.

It is important both theoretically and experimentally to determine the potential criteria that affect the causes of the truck driver's distraction and to create a holistic framework that includes these criteria for an effective and successful logistics management for buyers and managers, especially for drivers. Therefore, after a detailed literature search, a total of nine important sub-criteria were determined under two main headings, inside and outside the research. The criteria and by whom they were used before are presented in Table 1.

Table 1. Driver distraction barriers

Main Dimensions	Sub-Barriers	Authors
Inside Vehicle	Working and resting times of drivers	Bunn et al. (2005); Horberry et al. (2021)
	Eating and drinking in the car	Young et al. (2008); Zhang et al. (2019)
	Aggressive driver behaviors	Cheung et al. (2018); Hoback (2019)
	Use of mobile phones	Bayly et al. (2008); Stavrinos et al. (2016); Ortiz et al. (2018)
Outside Vehicle	Looking at external objects	Smiley et al. (2004); Regan et al. (2008); Cunningham and Regan (2018)
	Age of the driver	Tefft (2017); Regev et al. (2018); Zhang et al. (2019)
	Experience of the driver	Ehsani et al. (2020); Park & Park (2021)
	Wage and overtime policy	Park et al. (2021); Chen et al. (2021)
	Situation of the roads	Hickman and Hanowski (2012); Olson et al. (2009); Claveria et al. (2019)

From the point of view of the holistic and systems approach, it can be said that the barriers under different recommendations may be related to each other and the order of weights may be different. In parallel with this purpose, the weight and order of each barrier will be found by using the BWM method.

3. Methods

BWM is a comparison-based multi criteria decision making method that compares the best determined criterion with other criteria and compares all other criteria with the worst determined criterion. The main difference of this method is determining the weights of the criteria by using an optimization model. So, this method is used to evaluate a set of alternates with respect to a set of decision criteria. Below, the application steps of the BWM are explained respectively (Rezaei, 2015).

Step 1: A number of decision criteria are set. In this step, the DM determines the n criteria $C = \{c_1, c_2, \dots, c_n\}$ used to give the decision, n denotes the total number of the criteria.

Step 2: The best (c_b) and worst (c_w) criteria are determined by the DM from the set of criteria. The criterion determined as the best is the most desired and most significant criterion. The worst criterion is the least desired and least significant criterion.

Step 3: The preference ratio of the criterion that is best (c_b) chosen according to all other criteria is determined for binary comparison. This preference ratio is expressed by the DM as a number between one and nine where one is 'equally significant' and nine is 'extremely significant'. Then a vector called 'Best-to-Others' (A_B) is reached that goes from best to others. This vector is as follows.

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn})$$

Each a_{Bj} in the A_B vector shows the preference of B, which is the best criterion, according to criterion j. Value is an integer number between one to nine. In addition, if $a_{BB} = 1$, so the most desired and most significant criterion will be compared with itself.

Step 4: The preference ratio of the criterion that is worst (c_w) chosen according to all other criteria is determined for binary comparison. This preference ratio is expressed by the DM as a number between one to nine as in Step 3. The vector emerges, which is the worst from the other criteria. Then a vector called 'Others-to-Worst' (A_W). This vector is as follows.

$$A_w = (a_{1W}, a_{2W}, \dots, a_{nW})^T$$

Each a_{iW} in the A_w vector, shows the preference of criterion j over the worst criterion W. In addition, $a_{WW} = 1$. This means that the worst criterion will be compared to itself.

Step 5: For each criterion, their optimal weight is determined $w^* = (w^{1*}, w^{2*}, \dots, w^{n*})$. The optimal weight for the criteria is $w_B/w_i = a_{Bi}$ and $w_i/w_w = a_{iw}$ for each pair of w_B/w_j and w_j/w_w, respectively $j = (1,2, \dots, n)$. The weight vector must not be negative and the total condition must be 1.
The problem equation is transferred to the following linear programming problem.

$$\min \xi$$
$$|w_B/w_j - a_{Bj}| \le \xi, \text{ for whole } j$$
$$|w_j/w_w - a_{jW}| \le \xi, \text{ for whole } j$$
$$\sum w_j = 1,$$
$$w_j \ge 0, \text{ for whole } j = 1,2, \dots, n$$

Step 6: With the completion and solving of all this model, optimum weights $(w_1{}^*, w_2{}^*, \dots, w_n{}^*)$ and ξ value are obtained. The value of ξ expresses the maximum absolute difference and the Consistency Ratio (CR) is used to control the reliability of the optimal weights and it expresses the reliability among the got weights and the binary comparison data ensured by the DM. CR is shown as follows.

$$CR = \xi^*/Consistency\ Index\ (CI)$$

CR is a number between zero to one ($CR \in [0, 1]$), zero indicates complete consistency. According to the c_w criterion, determining the largest a_{BW} preference ratio of the c_b criterion $(1,2, \dots, 9)$, the maximum ξ value emerges. These maximum values are used as CI. It turned out that the higher the value, the weaker their consistency ratio and the less reliable the comparisons, and the lower the value, the higher the consistency ratio.

4. Data Collection

As stated in the previous section, a total of nine barriers were determined, including two main dimensions, inside and outside the vehicle. The barriers were approved by taking the opinions of five experts who have at least ten years of experience in logistics and work in senior positions. The BWM matrix was then presented to the same experts for weighting and ranking these barriers. The BWM application was completed by experts working in senior positions in different logistics companies. In this study, the experts whose opinions were taken are authorized persons working in the field of supply chain operations in Turkey's largest logistics companies. Information about these experts is shown in Table 2.

Table 2. Information about experts

Expert	Area of Expertise	Position	Experience
1	Food	Engineer	6
2	Purchasing	Manager	>15
3	Production Planning	Manager	10
4	Supply Chain	Director	7
5	Marketing	Manager	7

The research methodology was explained in detail in the previous section. The proposed mathematical model is coded and solved by EXCEL. The answers from experts were put into the mathematical model and the model was run. By solving the BWM model, the weights of different criteria and sub-criteria were determined. The results are discussed in the next section.

5. Results and Discussion

Before analyzing the weights of each barrier, we should check to what extent the results are reliable. The Consistency Ratio (CR) of the pairwise comparison data provided by the decision-makers must be looked at to check the reliability of the barrier weights obtained. As seen on Table 3, consistency values of the inside and outside vehicles are 0,303 and 0,213, respectively. This means that the closer the ξ^* to zero is the better, so there is not any problem about the reliability of the data and analysis.

Table 3. General results of the BWM

Dimension	ξ^*	**Weight**	**Rank**	**Barriers**	**Local Weight**	**Rank**	**Global Weight**	**Global Rank**
Inside Vehicle	0.303	0.4375	1	C1-driver fatigue	0.1573	2	0.0702	6
				C2-eating and drinking in the car	0.1179	3	0.0843	4
				C3-aggressive driver behaviors	0.0842	4	0.0526	7
				C4-use of mobile phones	0.6404	1	0.2732	1
				Total	**1.0000**		**0.4804**	
Outside Vehicle	0.213	0.125	2	C5-looking at external objects	0.5530	1	0.0843	5
				C6-age of the driver	0.1531	2	0.2107	2
				C7-experience of the driver	0.1094	4	0.1405	3
				C8-wage and overtime policy	0.0567	5	0.0526	8
				C9-situation of the roads	0.1276	3	0.0312	9
				Total	**1.0000**		**0.5195**	

Based on the global weights obtained by BWM, the ‘inside vehicle’ dimension is the more important than 'outside vehicle' dimension. Moreover, the use of mobile phones (C4) is the most important barrier among the sub-barriers. If it is necessary to sort among all barriers; age of the driver (C6), the experience of the driver (C7) and eating & drinking in the car (C2) follow looking at external objects (C5), respectively. Surprisingly, the aggressive driver behaviors (C3) barrier came in at the bottom of the overall barrier ranking.

It is clearly seen that situation of the roads (C9) is the least important one with value of 0.0312. Wage and overtime policy (C8) with the value of 0.0526 was given the second-lowest priority. A graphical representation of the results is presented in Figure 1. Based on these results, this study gives the reader a comprehensive insight into how detected barriers affect truck driver performance. Therefore, this framework is a roadmap that is designed with a holistic view to guide manufacturers, logistics parties and even policy and decision-makers.

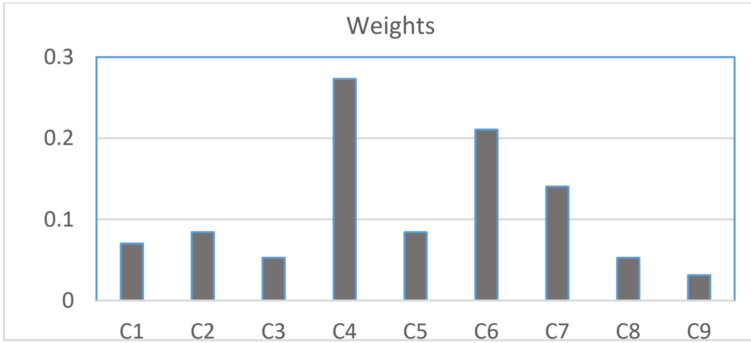

Figure 1. Weights of each barrier

6. Conclusion

The increased e-commerce volume, especially with the pandemic, has shown us that the supply chain should never be broken. Transportation, which is the most important element that connects the rings along the chain, has become more important. In the face of this situation, almost the whole world has faced the problem of truck driver shortage that has never been mentioned before

The accident caused by the truck drivers, which we already have problems with in terms of numbers, causes huge losses in the chain such as high cost, time and stock out. Looking at the literature, we found that there is no current study on this subject. For these reasons, the main research subject of this study is to determine the barriers of truck drivers that can cause accidents and to determine the order of importance of these detected barriers. BWM is applied to find the answers of all these questions.

Based on the results use of mobile phones is the most important barriers among the sub-barriers. If it is necessary to sort among all barriers; age of the driver, experience of the driver and eating & drinking in the car follow looking at external objects, respectively. Surprisingly, aggressive driver behaviors barrier came in at the bottom of the overall barrier ranking.

Based on these results, this study gives the reader a comprehensive insight into how detected barriers affect truck driver performance. Therefore, this framework is a roadmap that is designed with a holistic view to guide manufacturers, logistics parties and even policy and decision-makers. This study is a first attempt to investigate the potential effects of truck drivers on items that could cause an accident. Future studies can be extended to develop and analyze different applications so that the detected barriers can be removed in real life. This study was conducted in a developing country. Comparative results can be obtained with a study to be conducted in developed countries.

References

Bayly, M., Young, K. L., and Regan, M. A., Sources of distraction inside the vehicle and their effects on driving performance, *Driver distraction: Theory, effects, and mitigation,* pp. 191, CRC Press, 2008.

Bunn, T. L., Slavova, S., Struttmann, T. W., and Browning, S. R., Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries, *Accident Analysis & Prevention*, vol. 37(5), pp. 862-869, 2005.

Chen, G. X., Sieber, W. K., Collins, J. W., Hitchcock, E. M., Lincoln, J. E., Pratt, S. G., and Sweeney, M. H., Truck driver reported unrealistically tight delivery schedules linked to their opinions of maximum speed limits and hours-of-service rules and their compliance with these safety laws and regulations. *Safety Science*, vol.133, 105003, 2021.

Cheung, E., Bera, A., and Manocha, D., Efficient and safe vehicle navigation based on driver behavior classification. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops* (pp. 1024-1031), 2018.

Chevalier S., Retail e-commerce sales worldwide from 2014 to 2024 (in billion U.S. dollars), *Statista,* Available: https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/, Jul 7, 2021.

Chowdhury, P., Paul, S. K., Kaisar, S., and Moktadir, M. A., COVID-19 pandemic related supply chain studies: A systematic review, *Transportation Research Part E: Logistics and Transportation Review*, vol. 148, 102271, 2021.

Claveria, J. B., Hernandez, S., Anderson, J. C., and Jessup, E. L., Understanding truck driver behavior with respect to cell phone use and vehicle operation, *Transportation research part F: traffic psychology and behaviour*, vol.65, pp. 389-401, 2019.

Cunningham, M. L., and Regan, M. A., Driver distraction and inattention, *Safe mobility: Challenges, methodology and solutions,* Emerald Publishing Limited, 2018.

Donmez, B., Boyle, L., and Lee, J. D., Taxonomy of mitigation strategies for driver distraction*. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting* vol. 47, no. 16, pp. 1865-1869, Sage CA: Los Angeles, CA: SAGE Publications, 2003.

Donmez, B., Boyle, L. N., and Lee, J. D.,The impact of distraction mitigation strategies on driving performance, *Human factors*, vol.48(4), pp. 785-804, 2006.

Ehsani, J. P., Gershon, P., Grant, B. J., Zhu, C., Klauer, S. G., Dingus, T. A., and Simons-Morton, B. G. , Learner driver experience and teenagers' crash risk during the first year of independent driving. *JAMA pediatrics*, vol. 174(6), 573-580, 2020.

Federal Motor Carrier Safety Administration (FMCSA), Summary of Hours of Service Regulation. Available: https://www.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations, Sep 28, 2020.

Ferreira, S., Kokkinogenis, Z., and Couto, A., Using real-life alert-based data to analyse drowsiness and distraction of commercial drivers, *Transportation research part F: traffic psychology and behaviour*, vol. 60, pp. 25-36, 2019.

Grozoubinski, D., No deal, no trucks? What a no-deal Brexit will mean for road transport, *LSE Brexit*, 2018.

Hickman, J. S., and Hanowski, R. J., An assessment of commercial motor vehicle driver distraction using naturalistic driving data, *Traffic injury prevention*, vol. 13(6), pp. 612-619, 2012.

Hoback, A. S., Relationships between aggressive driving behaviors, demographics and pareidolia. *Transportation Research Interdisciplinary Perspectives,* vol. 2, 100037, 2019.

Horberry, T., Mulvihill, C., Fitzharris, M., Lawrence, B., Lenné, M., Kuo, J., and Wood, D., Human-Centered Design for an In-Vehicle Truck Driver Fatigue and Distraction Warning System. *IEEE Transactions on Intelligent Transportation Systems,* 2021.

Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., and Ramsey, D. J., The impact of driver inattention on near-crash/crash risk: an analysis using the 100-car naturalistic driving study data. Report No. DOT HS 810 594, *National Highway Traffic Safety Administration*, Washington, D.C., 2006.

Lee, J. D., Hoffman, J. D., and Hayes, E., Collision warning design to mitigate driver distraction, *Proceedings of the SIGCHI Conference on Human factors in Computing Systems*, pp. 65-72, 2004.

Lee, J. D., Young, K. L., and Regan, M. A., Defining driver distraction*, Driver distraction: Theory, effects, and mitigation*, vol. 13(4), pp. 31-40, 2008.

Masood, S., Rai, A., Aggarwal, A., Doja, M. N., and Ahmad, M., Detecting distraction of drivers using convolutional neural network, *Pattern Recognition Letters*, vol. 139, pp. 79-85, 2020.

McDonald, A. D., Ferris, T. K., and Wiener, T. A., Classification of driver distraction: A comprehensive analysis of feature generation, machine learning, and input measures, *Human factors,* vol. 62(6), pp. 1019-1035, 2020.

NHTSA: U.S. Department of Transportation, National Highway Traffic Safety Administration, Driving Safely While Aging Gracefully, Available: https://www.nhtsa.gov/older-drivers/driving-safely-while-aging-gracefully, Accessed on 25 November 2021.

Olson, R. L., Hanowski, R. J., Hickman, J. S.,and Bocanegra, J., Driver distraction in commercial vehicle operations, Report No. FMCSA-RRR-09-042, *U.S. Department of Transportation*, Washington, D.C., 2009.

Ortiz, C., Ortiz-Peregrina, S., Castro, J. J., Casares-López, M., and Salas, C., Driver distraction by smartphone use (WhatsApp) in different age groups. *Accident Analysis & Prevention*, vol.117, pp. 239-249, 2018.

Park, D. E., and Park, S. E., Factors affecting perceived safety and enjoyment based on driver experience. Transportation Research Part F: *Traffic Psychology and Behaviour,* vol. 83, 148-163, 2021.

Park, J., Lee, S., Oh, C., and Choe, B., A data mining approach to deriving safety policy implications for taxi drivers. *Journal of Safety Research*, vol. 76, 238-247, 2021.

Ranney, T. A., Garrott, W. R., and Goodman, M. J., NHTSA driver distraction research: Past, present, and future, no. 2001-06-0177, *SAE Technical Paper*, 2001.

Regan, M. A., and Hallett, C., Driver distraction: Definition, mechanisms, effects, and mitigation, *Handbook of traffic psychology,* pp. 275-286, Academic Press, 2011

Regan, M. A., Hallett, C., and Gordon, C. P., Driver distraction and driver inattention: Definition, relationship and taxonomy. *Accident Analysis & Prevention*, vol. 43(5), pp. 1771-1781, 2011.

Regan, M. A., Lee, J. D., and Young, K., Driver distraction: Theory, effects, and mitigation, *CRC press*, 2008.

Regev, S., Rolison, J. J., and Moutari, S. (2018). Crash risk by driver age, gender, and time of day using a new exposure methodology. *Journal of Safety Research*, vol. 66, 131-140, 2018.

Rezaei, J., Best-worst multi-criteria decision-making method. *Omega*, 53, 49-57, 2015.

Schwarz, C., Brown, T., Lee, J., Gaspar, J., and Kang, J., The detection of visual distraction using vehicle and driver-based sensors, *SAE Technical Paper*, no. 2016-01-0114, 2016.

Smiley, A., Smahel, T., and Eizenman, M., Impact of video advertising on driver fixation patterns. *Transportation Research Record*, vol. 1899(1), pp. 76–83, 2004.

Stavrinos, D., Heaton, K., Welburn, S. C., McManus, B., Griffin, R, and Fine, P. R., Commercial truck driver health and safety: Exploring distracted driving performance and self-reported driving skill, *Workplace health & safety*, vol. 64(8), pp. 369-376, 2016.

Tefft, B., Rates of motor vehicle crashes, injuries and deaths in relation to driver age, United States, 2014-2015. *AAA Foundation for Traffic Safety*, 2017.

Treat, J. R., A study of precrash factors involved in traffic accidents, *HSRI Research review*, 1980.

World Health Organization, Mobile phone use: a growing problem of driver distraction, Available: https://apps.who.int/iris/bitstream/handle/10665/44494/9789241500890_eng.pdf, 2011.

Wu, X., Zhang, C., and Du, W., An analysis on the crisis of "chips shortage" in automobile industry-Based on the double influence of COVID-19 and trade friction, *In Journal of Physics: Conference Series,* IOP Publishing. vol. 1971, No. 1, pp. 012100, 2021.

Young, K., Factors moderating the impact of distraction on driving performance and safety, *Driver distraction: Theory, effects, and* mitigation, pp. 353-370, CRC Press, 2008.

Young, M. S., Mahfoud, J. M., Walker, G. H., Jenkins, D. P., and Stanton, N. A., Crash dieting: The effects of eating and drinking on driving performance. *Accident Analysis & Prevention*, vol. 40(1), 142-148, 2008.

Zhang, F., Mehrotra, S., and Roberts, S. C., Driving distracted with friends: Effect of passengers and driver distraction on young drivers' behavior, *Accident Analysis & Prevention*, vol. 132, 105246, 2019.

Biographies

Cansu Akçiçek has been a Research Assistant in Graduate School of Yasar University. She completed her undergraduate and Master's degree in Industrial Engineering and currently she is a PhD student in Business Administration at Yasar University. Her Master's thesis is on electric vehicle routing problems, and her research interests are vehicle routing problems, supply chain management and optimization.

Yucel Ozturkoglu has been a Professor in the Department of Logistics Management at Yasar University. After completing her undergraduate studies at the Faculty of Engineering/Çankaya University, she completed MBA at the Erciyes University. She also completed her Master and Ph.D. at the Auburn University from the Industrial and System Engineering Department. Her research interest includes supply chain management, production management and decision-making models.

Omer Ozturkoglu has been an Assoc. Professor in the Department of Business Administration at Yasar University. In 2006, he started his doctoral studies at the Department of Industrial and Systems Engineering at Auburn University (Alabama, USA). He also got a Master in Industrial and Systems Engineering in 2010. In 2011, he earned a Ph.D. degree with a dissertation entitled "New warehouse designs: angled aisles and their effects on travel distance". His research interest includes logistics, warehouse management and production planning.