

Development of a Model for Evaluating the Efficiency of Public Transport Driver Behavior

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Abstract. This study presents a comprehensive evaluation of factors affecting the efficiency of public transport driver behavior in Bangkok, Thailand. Employing a mixed-methods approach, we analyzed data from 767 public transport drivers using a structured questionnaire, supplemented by interviews with 12 management-level executives. The core of our research involved a path analysis using the Analysis of Moment Structures (AMOS) to identify key factors influencing driver efficiency. The findings from the path analysis revealed significant relationships, with a measurement model demonstrating a Chi-square of 26.748, $df=17$, $p=.62$, $CMIN/DF=1.573$, $CFI = 0.993$, $AGFI=.977$, $GFI=.980$, $RMSEA=.0027$, $RMR=.012$. Building on these insights, we developed a conceptual model focused on enhancing driver performance within public transport systems. The model integrates empirical evidence and theoretical underpinnings to offer practical strategies for improving public transportation service quality and operational efficiency. It is designed as a diagnostic tool for public transport authorities and policy-makers to assess, monitor, and optimize driver behavior. This research contributes to the literature by providing a detailed analysis of driver behavior dynamics and proposing a framework for practical implementation in the logistics and public transport sectors. The study underscores the importance of understanding and managing driver perceptions, working conditions, and internal rules to foster safer and more efficient transport systems.

Keywords: Quality Service, Public Transport, Public Transport Driver, Logistics Activity.

1. Introduction

Ensuring safe and high-quality public transport is a pivotal challenge in contemporary urban settings. The urgency of this issue is underscored by global efforts, such as the World Health Organization's initiative to curtail road traffic injuries and the United Nations General Assembly's goal to halve road fatalities and injuries by 2030. The rising incidence of road accidents, often resulting in non-fatal injuries and disabilities, underscores the gravity of this public health concern (World Health Organization, 2021).

In Thailand, a detailed examination of accident statistics reveals a discernible increase in road accidents from 2015 to 2019, with a subsequent decline during the COVID-19 pandemic due to travel restrictions (Department of Land Transport, 2021). This pattern suggests a direct correlation between travel frequency and the incidence of road accidents. Importantly, passenger complaints and accident report frequently implicate driver behavior—ranging from reckless driving to discourtesy and failure to adhere to designated stops—as a primary factor in these incidents. These behaviors, while correctable, contribute significantly to the public's diminishing confidence in public transport systems.

The economic repercussions of such driver-induced incidents are equally concerning. Over a five-year span, the financial losses associated with these accidents have escalated, signaling an alarming trend. This raises a critical question: Can we identify and model the factors influencing public transport driver behavior to mitigate these negative outcomes? A model that effectively addresses this issue could reduce road accidents and restore public confidence in transport systems. This, in turn, could lead to a decline in private car usage, promoting a more sustainable and efficient urban transport environment.

Given the complexity of this challenge, it is essential to undertake an empirical investigation into developing a model for evaluating the efficiency of public transport driver behavior, with a specific focus on the context of Bangkok, Thailand. This study aims to fill a significant gap in existing research by comprehensively analyzing the factors influencing driver behavior and proposing actionable strategies for improvement. In doing so, it seeks to contribute to the broader goal of enhancing public transport safety and service quality, thereby fostering societal well-being and progress.

2. Research Objective

The overarching aim of this study is to delve into the intricacies of public transport driver behavior and its implications for the efficiency and safety of public transport systems. This exploration is pursued through the development and empirical testing of a model designed to evaluate the multifaceted factors influencing driver behavior in Bangkok's public transport sector. Specifically, the research is driven by two primary objectives

2.1. Path Analysis of Factors Affecting the Efficiency of Public Transport Driver Behavior

The first objective involves conducting a path analysis to dissect and understand the complex interrelationships among various factors that influence the efficiency of public transport driver behavior. This will entail a detailed examination of direct and indirect influences, mediator and moderator effects, and the overall structure of relationships among observed and latent variables. By employing sophisticated statistical techniques, the study aims to uncover the underlying patterns and constructs that characterize driver behavior in the context of public transport, thereby providing a nuanced understanding of the drivers' operational environment, psychological disposition, and behavioral tendencies.

2.2. Development of a Model for Evaluating the Efficiency of Public Transport Driver Behavior

Building upon the insights garnered from the path analysis, the second objective is to develop a comprehensive model for evaluating the efficiency of public transport driver behavior. This model will

be designed to serve as a diagnostic and strategic tool, enabling public transport authorities and policymakers to assess, monitor, and enhance driver performance effectively. The model will integrate the key factors identified through the empirical analysis, aligning with theoretical frameworks and practical considerations. It will aim to provide a robust and user-friendly framework that can be adopted and adapted for continuous improvement in driver training, performance assessment, and policy formulation.

3. Literature Review

The literature review for this study centers around the critical examination of driving behavior, specifically within the context of public transportation. A key tool in this domain is the Driver Behavior Questionnaire (DBQ), which encapsulates four primary components: 1) Lapses/Slips, 2) Errors, 3) Ordinary Violations, and 4) Aggressive Violations. These components have been extensively studied in various contexts, as evidenced by the research of Ang, et al., (2019), Koppel, et al. (2019), Koppel, et al. (2018), Soliman, et al. (2018), Hussain & Shi (2020), Ge, et al., (2020), Sullman, et al., (2019), Jiang & Rau (2018), Mehdizadeh, et al. (2018), and Ortiz, et al. (2018). This tool is crucial for understanding the nuances of driver behavior and forming the basis of our model.

Moreover, an interesting dimension emerged in the literature regarding Positive Behavior (Shen, et al., 2018; Ge, et al., 2020; Maslač, et al., 2018), suggesting that not all driver actions are negative or risky. This perspective is essential in developing a balanced and realistic model of driver behaviour.

Our literature review identified three main independent variables influencing the DBQ: 1) Perception, 2) Condition, and 3) Internal Rules. These variables, explored in studies by Shams, et al., (2021), Nævestad, et al., (2019) and Jiang & Rau (2018), provide a foundational understanding of the factors shaping driver behaviour.

Furthermore, the involvement of drivers in no-fault and at-fault accidents, as discussed in the works of Shams, et al., (2020). Nævestad, et al., (2019). Mohamed & Bromfield (2017) and Tao, et al., (2017), helps in framing these behaviors within the context of road safety.

Incorporating global perspectives, we reviewed studies addressing the broader challenges in public transportation. For instance, Sundström (2008) highlights the issue of inefficient public transportation in underdeveloped areas, often exacerbated by driver behavior. Goudreau (2019) discusses diverse problems in Indonesia, from congestion to pollution, attributing these partly to driver behavior and social factors. These insights are critical for contextualizing our study within a global framework, emphasizing the multifaceted nature of the problem.

Additionally, research on driver behaviour in various cultural contexts (Zhou, et al., 2020; Scott-Parker & Oviedo, 2017) offers a comparative perspective, underscoring the need for a model that is adaptable to different environments.

Our review also encompassed technological approaches in analyzing driver behavior, such as the use of Discrete Wavelet Transformation and Adaptive Neuro-Fuzzy Inference System (Dobránský & Pollák, 2021) and Mobile Crowd Sensing (Limsoonthrakul, et al., 2021). These studies provide insights into innovative data collection and analysis methods in driver behaviour research.

Lastly, we considered the legal and educational aspects of driver training and qualification, as outlined in the legislation of the Republic of Indonesia (Rehrl et al., 2014) and standards stipulated in Kepmendiknas Number 23 of 2006 (Firat & UĞURLU, 2018). Understanding these regulatory frameworks is essential for developing a comprehensive model that aligns with legal and educational standards.

Overall, this literature review sets the stage for our research by synthesizing diverse perspectives and findings on driver behavior, which are instrumental in shaping the model for evaluating the efficiency of public transport driver behavior in Bangkok.

4. Research Methods

This research employed a mixed-methods approach, integrating both quantitative and qualitative methodologies to develop a comprehensive understanding of the factors influencing public transport driver behavior in Bangkok. The methodological framework was meticulously designed to ensure a systematic and thorough exploration of the research objectives.

Quantitative Research: The quantitative phase of the study was primarily focused on testing and validating theoretical concepts using statistical analysis. This involved the following key steps:

- **Data Collection:** Data was gathered through a structured questionnaire distributed to a sample of 767 public bus drivers in Bangkok, Thailand. Participants were selected based on criteria such as years of experience, routes driven, and employment status to ensure a representative sample of the driver population.
- **Statistical Analysis:** The collected data was analyzed using the Statistical Package for the Social Sciences (SPSS) and Analysis of Moment Structures (AMOS) software. These advanced statistical tools enabled examining complex relationships between variables and testing the proposed model's fit and efficacy.

Qualitative Research: The qualitative aspect of the study aimed to build conceptual models grounded in reality and informed by inductive reasoning. This phase encompassed:

- **Preliminary Observations and Interviews:** Initial observations and in-depth interviews were conducted to gather insights into the drivers' behaviors, attitudes, and perceptions. This phase helped refine the questionnaire and provided context for interpreting the quantitative data.
- **Executive Interviews:** Utilizing the insights gained from the quantitative data, a sample of 12 executives at the management level was selected for interviews. The executive interview form, validated by expert review, facilitated in-depth discussions to gain managerial perspectives on driver behavior, operational challenges, and policy implications.

Integrated Approach: The research methodology was structured to allow for an iterative process, where insights from one method informed the other. The quantitative data provided a solid foundation for statistical analysis, while the qualitative data offered nuanced understandings of the drivers' experiences and managerial viewpoints. This comprehensive approach ensured a holistic understanding of the research problem, aligning the findings with the objectives of developing a model for evaluating the efficiency of public transport driver behaviour.

5. Research Results

5.1. Analyzing Path Analysis of Factors Affecting the Efficiency of Public Transport Driver Behavior

This section explores the interplay among causal, mediator, and dependent variables in determining public transport driver behavior efficiency. The study's hypothesis testing focused on three causal variables: Perception, Internal Rules, and Condition. The mediator variables included Aggressive Violations, Errors, Ordinary Violations, and Lapses/Slips, while the dependent variables were no-fault and at-fault accidents. The path analysis, illustrated in Figure 1, employed Structural Equation Modeling (SEM) to map these relationships.

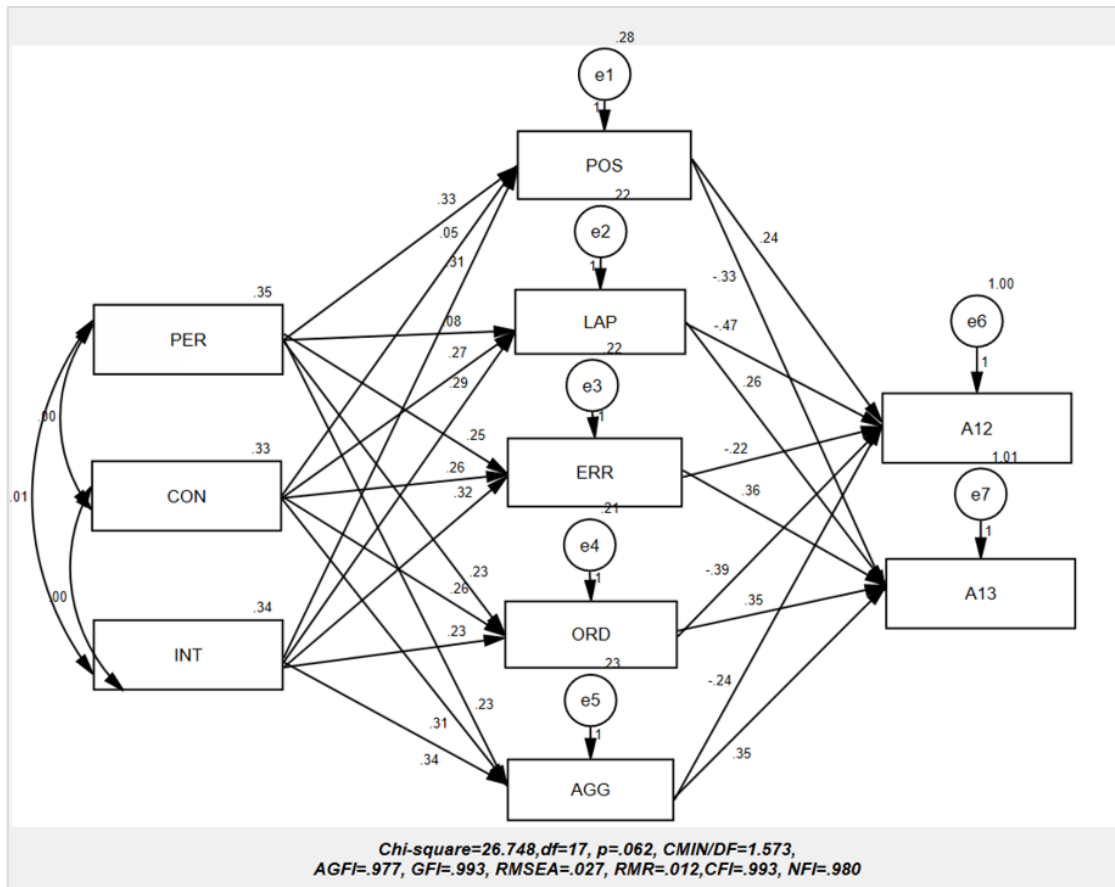


Fig. 1: Path Analysis with SEM.

In evaluating the model's fit with the empirical data, several key indices were analysed post-modification:

- Probability in Hypothesis Testing (P-value): The P-value should ideally be ≥ 0.05 . In this study, a P-value of 0.62 was obtained, indicating an acceptable probability level and suggesting the model's alignment with empirical data.
- Relative Chi-square Value (CMIN/DF): This index should ideally be ≤ 3.00 . The observed value was 1.573, further confirming the model's consistency with empirical data.
- Comparative Fit Index (CFI): A value of ≥ 0.90 is desirable for model validation. The achieved CFI was 0.993, indicating an excellent fit.
- Adjusted Goodness of Fit Index (AGFI): With a threshold of ≥ 0.85 , the obtained AGFI of 0.977 surpasses this benchmark, supporting the model's validity.
- Root Mean Square Residual (RMR): Ideally, RMR should be ≤ 0.08 . The model achieved an RMR of 0.012, which is within the acceptable range.
- Root Mean Squared Error of Approximation (RMSEA): RMSEA should be ≤ 0.08 for model appropriateness. The calculated RMSEA was 0.027, further endorsing the model's suitability.
- Normed Fit Index (NFI): A value of ≥ 0.90 is desired. The model's NFI was 0.993, highlighting its consistency with the empirical data.
- Goodness of Fit Index (GFI): A GFI of ≥ 0.90 is indicative of a good model fit. The study recorded a GFI of 0.980, confirming the model's robustness.

These indices collectively suggest that the structural equation model is appropriately aligned with the empirical data, offering a reliable framework for understanding the dynamics of public transport driver behaviour efficiency. The detailed and graphical representation of these relationships in Figure 1 enhances comprehension and provides a visual summary of the key relationships and findings.

5.2. Development of a Model for Evaluating the Efficiency of Public Transport Driver Behavior

Utilizing the Path Analysis method, this study has culminated in the creation of a comprehensive, academically grounded model. This model, designed to evaluate the efficiency of public transport driver behavior, contributes significantly to the management of public transport drivers. The model's conceptual framework, informed by both theory and empirical findings, is illustrated in Figure 2.

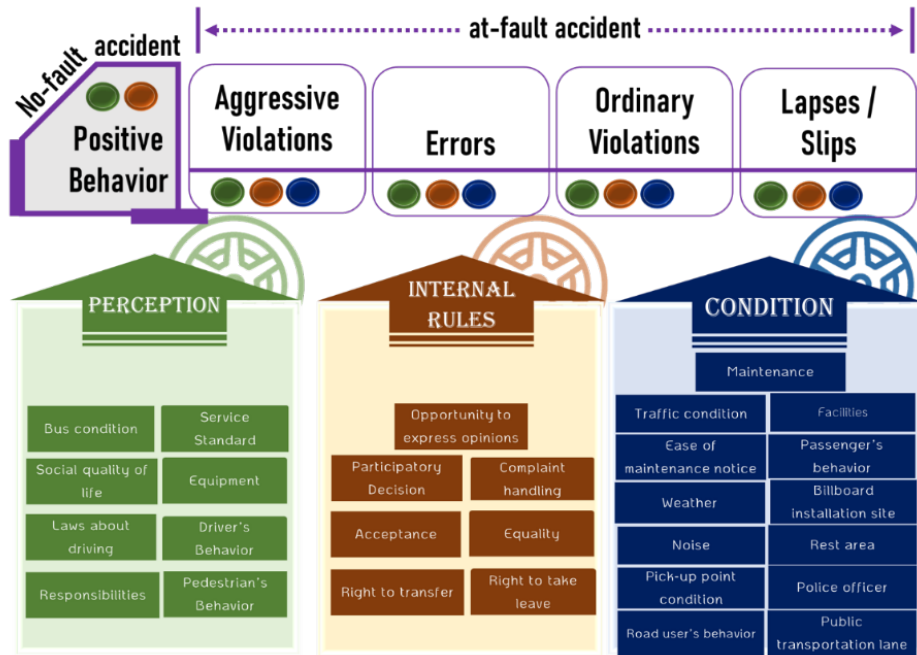


Fig. 2: Model for Evaluating the Efficiency of Public Transport Driver Behaviour.

The model's application is intended to enhance the operational value of public transport systems. It encapsulates two primary guidelines:

5.2.1 Developing Practical Guidelines from Model Factors

This section focuses on developing practical guidelines derived from the model's factors, particularly emphasizing the role of driver 'Perception' in influencing 'Positive Behaviour,' which subsequently impacts the incidence of no-fault accidents.

Table 1: Impact of Perception on Positive Behaviour and No-fault Accidents

Causal Variables	Mediator Variables	Dependent Variables	Interpretation
Perception	Positive Behavior	No-fault accident	Perception had a positive influence on mediator variables toward no-fault accidents.

The analysis reveals a significant correlation where the causal variable 'Perception' markedly influences the mediator variable 'Positive Behaviour.' This influence extends to the dependent variable, showing a positive impact on the occurrence of at-fault accidents. Such insights underscore the importance of focusing on driver 'Perception' to cultivate 'Positive Behaviour' among public bus drivers.

Through the interpretation of these findings, the model for evaluating the efficiency of public transport driver behaviour can be further developed. It involves fostering driver awareness and understanding of critical aspects, such as the proper use of safety equipment and adherence to operational standards. This comprehension should encompass standards of practice for passenger services, legal requirements for public transport vehicles, and responsibilities in the event of malfunctions or accidents.

Crucially, drivers' awareness of how their performance impacts societal quality of life is vital. This includes understanding their behaviours and those of other road users. Such informed perceptions are likely to result in positive driving behaviours, including maintaining proper lane discipline, using the horn judiciously, keeping safe distances between vehicles, yielding to pedestrians, and managing speed appropriately to enhance road safety and reduce traffic issues.

Table 2: Impact of Conditions on Aggressive Violations and At-fault Accidents

Causal Variables	Mediator Variables	Dependent Variables	Interpretation
Condition	Aggressive Violations	At-fault accident	The condition had an influence on the mediator variables (Aggressive Violations) which had a positive effect on at-fault accidents.

The analysis of this research offers crucial insights into the role of working conditions ('Condition') in influencing 'Aggressive Violations', which in turn significantly impact the occurrence of at-fault accidents. This underscores the need for a focused approach on improving working conditions as a key strategy in the management of public transport drivers.

The influence curve analysis identified 'Condition' as a primary factor influencing 'Aggressive Violations'. These findings highlight the direct correlation between the working environment of bus drivers and the incidence of at-fault accidents. Consequently, enhancing the working conditions for bus drivers emerges as a pivotal strategy for reducing aggressive driving behaviours and thereby minimizing at-fault accidents.

The interpretation of these results leads to actionable strategies for improving the working environment of bus drivers:

- **Vehicle and Facility Maintenance:** Regular checks and maintenance of buses are essential to ensure driver safety and vehicle reliability. Any necessary repairs should be identified and addressed promptly to avoid operational disruptions.
- **Mitigating Noise Disturbance:** External, passenger, and engine noise can significantly impact driver concentration and performance. Reducing these disturbances is crucial for creating a more conducive working environment.

- Improving Passenger Pick-up Points: Many current bus stops are inadequately designed, posing risks to both passengers and drivers. Improving the conditions of these areas, including addressing road surface issues and visibility problems caused by billboards, is imperative.
- Addressing Traffic and Weather Conditions: Heavy traffic and adverse weather conditions can add to the stress and challenges faced by drivers. Implementing strategies to assist drivers in these conditions can significantly improve their ability to perform their duties safely and efficiently.
- Creating a Supportive Work Culture: Encounters with difficult passengers or other road users can lead to heightened stress levels in drivers. Establishing a supportive work culture that includes training on managing these interactions can help in mitigating aggressive responses.

The findings suggest that policy-level interventions are necessary to address the root causes of aggressive driving behaviours. This includes establishing clear operational guidelines and penalties, and offering training to drivers on emotional regulation to prevent aggressive responses. Furthermore, incorporating drivers' perspectives into policy-making can lead to more effective and tailored solutions, ultimately enhancing the safety and efficiency of public transport operations.

Table 3: Influence of Internal Rules on Aggressive Violations and At-fault Accidents

Causal Variables	Mediator Variables	Dependent Variables	Interpretation
Internal Rules	Aggressive Violations	At-fault accident	Internal Rules had an influence on the mediator variables (Aggressive Violations) positively affecting the occurrence of at-fault accidents.

The influence curve analysis within this research has illuminated the significant role that 'Internal Rules' play in modulating 'Aggressive Violations', which are closely linked to the incidence of at-fault accidents. This finding underscores the importance of effectively managing and participating in the creation of Internal Rules within public transport systems.

The analysis found that the causal variables associated with 'Internal Rules' profoundly influence 'Aggressive Violations', leading to a higher likelihood of at-fault accidents. This suggests a critical need to focus on developing and enforcing Internal Rules to reduce aggressive driving behaviours among public bus drivers.

Strategies for Reducing Aggression through Internal Rules:

- Participative Policy Development: Encouraging driver involvement in the formulation of Internal Rules is crucial. Allowing drivers to express their opinions and experiences during decision-making processes can lead to more relevant and effective rules.
- Addressing the Root Causes of Aggression: Understanding the underlying causes of aggressive behavior is essential. This can be achieved by fostering open communication channels and considering drivers' feedback in identifying stressors and operational challenges they face.
- Fairness in Workplace Practices: Ensuring fairness in transfers, rotations, leave policies, and the handling of complaints is vital. Equitable treatment of drivers contributes to a positive work environment, reducing the likelihood of aggression.
- Clear and Just Personnel Policies: Developing clear and fair personnel policies that are well communicated to all drivers is essential. These policies should mitigate factors contributing to aggressive behavior while ensuring accountability.

By implementing these strategies, public transport systems can effectively lessen the occurrence of Aggressive Violations among drivers, thereby reducing the frequency of at-fault accidents. The proactive involvement of drivers in creating and understanding Internal Rules can lead to more responsible and safer driving behaviours.

5.2.2 Development Approach for Formulating Indicators to Evaluate the Efficiency of Public Transport Driver Behavior

This research provides a structured approach for developing indicators that can standardize control measures and performance appraisals for public bus drivers. These indicators are crucial for enhancing the overall effectiveness of transport organizations by focusing on the pivotal role of employees. The following steps outline the process for creating these performance indicators:

- **Analyze Organizational Objectives and Activities:** Assess the organization's objectives, strategies, plans, and projects related to public bus drivers. Ensure that these elements align with real-world conditions to produce tangible outcomes.
- **Identify Key Monitoring and Evaluation Issues:** Determine the issues that need constant monitoring and evaluation throughout the operational process. This includes assessing the input reflecting the actual performance of bus drivers and its impact on long-term outcomes.
- **Select Relevant Issues Affecting Driver Performance:** Choose the most pertinent issues that influence the success or challenges faced by public bus drivers. These issues should be continuously monitored and assessed for their impact on driver performance.
- **Determine Appropriate Indicators:** Carefully select the most relevant indicators across various dimensions to accurately gauge driver performance and operational efficiency.
- **Establish a Data Management System:** Implement a system for storing and processing data related to driver performance. This system should allow for the regular assessment of performance metrics, facilitating comparisons over time to discern trends and make necessary adjustments.

This methodical approach to developing performance indicators is designed to provide transport organizations with the tools to effectively assess and enhance driver efficiency. By focusing on key aspects of driver behaviour and operational factors, these indicators offer a comprehensive means to evaluate and improve public transport service quality.

6. Summary and Discussion

6.1. Summary

This study highlights critical opportunities for enhancing work efficiency in public transport organizations by examining driver behaviors in recurring incidents. It is crucial to recognize that these behaviors, while sometimes being limitations, also offer opportunities for improvement when there is cooperation from drivers. This cooperative approach enables organizations to adapt effectively to environmental changes, mitigate risks, and manage costs associated with accident compensation more efficiently. Such management has a direct impact on reducing travel expenses for passengers, thereby enhancing public trust and satisfaction.

Proactive engagement by executives is paramount in this context. Rather than adopting a reactive stance, waiting for problems to arise before addressing them, there is a substantial benefit in anticipating and preventing potential issues. By incorporating driver performance quality into policy-making, organizations can not only maintain but enhance their public image and competitive edge. This strategic focus is key to achieving operational cost efficiencies and realizing the organization's broader vision.

Considering both the direct and indirect impacts of supply chains on logistics activities, the study underscores the importance of driver quality in achieving time and cost efficiency, thereby bolstering organizational credibility. In the realm of public transportation, where drivers are a crucial asset, their behavior and performance significantly influence overall service quality and goal attainment.

The implementation of these findings involves a strategic focus on managing the visible working conditions. This approach creates added value for services and can be articulated as guidelines within organizational management principles. These principles emphasize process

management and the development of driver quality to achieve organizational goals. Key aspects of this approach include:

- Identifying continuous responsiveness factors as pivotal inputs in the process.
- Establishing effective coordination points between different departments.
- Assessing potential risks associated with both input and output factors to ensure thorough monitoring and review processes.
- Clearly delineating responsibilities and administrative powers within the organization.

6.2. Discussion

The analysis and synthesis of the research results in "Development of a Model for Evaluating the Efficiency of Public Transport Driver Behavior" have led to significant insights regarding the variables influencing driver behavior. This discussion integrates findings from the literature review and aligns them with the empirical data collected in the study.

Independent Variables: The study identified three key independent variables impacting driver behaviour: 1) Perception, 2) Condition, and 3) Internal Rules. These variables align with the findings of several researchers in the field, notably Shams, et al. (2021), Nævestad, et al. (2019), and Jiang & Rau (2018). The consistency of these variables with existing literature underscores their relevance and validity in assessing driver behaviour in public transport.

Mediator Variables: Drawing from the Driver Behaviour Questionnaire (DBQ), the study incorporated four mediator variables: 1) Lapses/Slips, 2) Errors, 3) Ordinary Violations, and 4) Aggressive Violations. These variables are widely recognized in driver behaviour research, as evidenced by studies from Ang et al. (2019), Koppel, et al. (2019), Koppel, et al. (2018), Soliman, et al. (2018), Hussain & Shi (2020), Ge, et al., (2020), Sullman, et al., (2019), Jiang & Rau (2018), Mehdizadeh, et al. (2018), and Ortiz, et al. (2018), an additional mediator variable, Positive Behaviour, was integrated into the DBQ framework, resonating with the research of Shen et al. (2018), Ge et al. (2020), and Maslač, et al. (2018).

Dependent Variables: The study focused on two dependent variables: 1) participation in an at-fault accident and 2) participation in a no-fault accident. These variables are significant in the realm of driver behaviour studies, as they directly relate to the outcomes of driver actions and decisions. The relevance of these variables is supported by research from Shams, et al. (2021), Nævestad, et al. (2019), Mohamed & Bromfield (2017), and Tao et al. (2017). The impact of the mediator variables on these dependent variables, influenced indirectly by the independent variables, offers a comprehensive view of the factors contributing to driver behaviour in public transport.

7. Suggestion

The findings of this research have integrated key variables that are both theoretically significant and empirically validated through international research. These variables, gleaned from comprehensive databases and analyzed using advanced statistical methods, provide a robust basis for practical applications.

7.1. Suggestions for Research Findings Application

7.1.1 Policy Level:

Effective personnel management forms the cornerstone of organizational success, whether in logistics or other sectors. This research underscores the need for diverse management strategies that enhance awareness of perceptual changes, operating conditions, and rules that encourage appropriate behavior during work. By understanding these dynamics, executives and teams can identify new opportunities for improving work efficiency.

The implications of this study extend to risk management strategies that influence organizational costs. These strategies are particularly relevant in the context of public transport,

where accident-related expenses directly affect the travel costs borne by citizens. Therefore, a well-conceived driver management approach is not just about reducing risks and expenses; it's about creating an environment where better performance is encouraged and rewarded.

Managers and policymakers are advised to leverage the insights from this research in shaping policies, strategies, tactics, and operational guidelines. The focus should be establishing measures, rules, and regulations that effectively manage bus drivers in logistics and public transport. This approach is applicable across both public and private domains, where the goal is to foster a competitive advantage.

To substantiate these suggestions, reference should be made to the statistical analysis presented in the study, particularly the findings illustrated in Table 1, Table 2, and Table 3. These tables provide empirical evidence of the relationships between perceptions, conditions, internal rules, and driver behaviour.

7.1.2 Management Level:

Effective planning and decision-making at the management level require the integration of both internal and external information. This integration is crucial for adapting to the rapidly evolving logistics landscape, particularly in the management of bus driver operations. The findings of this research offer valuable insights for defining clear goals, directions, and key issues in management planning.

Managers are encouraged to use these findings to foster a proactive working style. Anticipating future events and being prepared, rather than merely reacting to challenges as they arise, is key to effective management. Management can maintain and enhance the organization's image by considering driver performance quality, leading to increased efficiency and reduced operating costs. Ultimately, this approach will contribute to the effective realization of the organization's vision.

7.1.3 Operational Level:

The research findings comprehensively review driver behaviors observed in real-world incidents. Recognizing that many issues faced by drivers are controllable yet require cooperation, these insights enable organizations to adapt to changing environments and mitigate risks more effectively. Such adaptations are not only beneficial for the organization but also contribute to the public good by improving the quality of life for citizens.

Increased vigilance and awareness of the direct impacts on drivers while performing their duties are essential. This includes addressing behaviours such as Lapses/Slips, Errors, Ordinary Violations, and Aggressive Violations. Promoting positive behaviour is key to developing better driving practices reflecting a shift from past organizational cultures. The research findings can empower personnel with the knowledge and understanding necessary to perform their tasks more effectively.

These insights should be viewed as inputs in a broader process aimed at achieving organizational goals. Managing actual working conditions throughout all processes and activities adds value to the logistics and transportation services. Thus, these findings can be formulated into practical guidelines for organizational management, emphasizing the importance of process management in the development of driver quality.

7.2. Suggestions for future research

- **Knowledge Expansion and Future Studies:** The variables synthesized and analyzed in this research provide a robust body of knowledge that can be instrumental in developing future research agendas. Future studies can build upon this foundation to explore additional aspects of driver behavior and efficiency in public transport.
- **Gender-Based Research:** A notable limitation of the current research is its focus solely on male drivers. Future research should aim to include female drivers, either by conducting parallel studies or focusing exclusively on female drivers. This approach will enable a more

comprehensive understanding of driver behavior across genders, which is crucial for developing inclusive policies and strategies in public transport systems.

- Exploring Diverse Driver Categories: The literature and variables pertinent to temporary bus drivers and drivers of other related vehicles warrant further exploration. Future studies should aim to identify and analyze new variables specific to these groups, thus enabling the formulation of new hypotheses and a deeper understanding of diverse driver behaviors within the public transport sector.
- National-Level Performance Indicators: Beyond the scope of logistics and public transportation businesses, the implications of this research can extend to developing performance indicators for drivers at a national level. This expansion would contribute significantly to enhancing service quality across broader transportation networks. Developing national-level indicators would provide a standardized approach to evaluating driver performance, contributing to improved public transportation systems and policy-making.

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References

- Ang, B. H., Chen, W. S., & Lee, S. W. (2019). The Malay Manchester Driver Behaviour Questionnaire: A cross-sectional study of geriatric population in Malaysia. *Journal of Transport & Health*, 14, 100573.
- Department of Land Transport. (2021). *The Transportation Statistics Annual Report 2021 (January)*. Retrieved 18 November 2021, http://www.dlt.go.th/minisite/m_upload/editorpic/technplan/files/Jan2564.pdf
- Dobransky, J., & Pollak, M. (2021). Monitoring and Evaluation of the Production Process of Automotive Connectors. *TEM Journal*, 10(2).
- FIRAT, Y., & UĞURLU, T. (2018, September). Automatic Garage Door System with Arduino For defined licence plates of cars. In *2018 International Conference on Artificial Intelligence and Data Processing (IDAP)* (pp. 1-8). IEEE.
- Ge, Y., Qu, W., Zhou, M., Ozkan, T., Bıçaksız, P. and Zhang, K., 2020. Psychometric adaption of the impulsive driver behavior scale in a Chinese sample. *Transportation research part F: traffic psychology and behaviour*, 68, pp.218-230.
- Goudreau, M. (2019). Understanding the Operational Attributes of Volunteer Driver Programs to Support Incorporation into Transportation Planning.
- Hussain, M., & Shi, J. (2020). Predictors of aberrant driving behaviors of Pakistani drivers by using proportional odds (PO) model. *Asian Transport Studies*, 6, 100005.
- Jiang, C., & Rau, P. L. P. (2018). Rule obedience as a mediator between normlessness and risky driving in hazy conditions. *Transportation research part F: traffic psychology and behaviour*, 59, 188-194.
- Koppel, S., Stephens, A. N., Bedard, M., Charlton, J. L., Darzins, P., Di Stefano, M., ... & Marshall, S. (2019). Self-reported violations, errors and lapses for older drivers: Measuring the change in frequency of aberrant driving behaviours across five time-points. *Accident Analysis & Prevention*, 123, 132-139.

- Koppel, S., Stephens, A. N., Charlton, J. L., Di Stefano, M., Darzins, P., Odell, M., & Marshall, S. (2018). The Driver Behaviour Questionnaire for older drivers: Do errors, violations and lapses change over time?. *Accident Analysis & Prevention*, *113*, 171-178.
- Limsoonthrakul, S., Dailey, M. N., Marikhu, R., Timtong, V., Chairat, A., Suphavilai, A., ... & Ekpanyapong, M. (2021). Design and Implementation of a Highly Scalable, Low-Cost Distributed Traffic Violation Enforcement System in Phuket, Thailand. *Sustainability*, *13*(3), 1210.
- Maslač, M., Antić, B., Lipovac, K., Pešić, D., & Milutinović, N. (2018). Behaviours of drivers in Serbia: Non-professional versus professional drivers. *Transportation research part F: traffic psychology and behaviour*, *52*, 101-111.
- Mehdizadeh, M., Shariat-Mohaymany, A., & Nordfjaern, T. (2018). Accident involvement among Iranian lorry drivers: Direct and indirect effects of background variables and aberrant driving behaviour. *Transportation research part F: traffic psychology and behaviour*, *58*, 39-55.
- Mohamed, M., & Bromfield, N. F. (2017). Attitudes, driving behavior, and accident involvement among young male drivers in Saudi Arabia. *Transportation research part F: traffic psychology and behaviour*, *47*, 59-71.
- Nævestad, T. O., Phillips, R. O., Laiou, A., Bjørnskau, T., & Yannis, G. (2019). Safety culture among bus drivers in Norway and Greece. *Transportation research part F: traffic psychology and behaviour*, *64*, 323-341.
- Ortiz, C., Ortiz-Peregrina, S., Castro, J. J., Casares-López, M., & Salas, C. (2018). Driver distraction by smartphone use (WhatsApp) in different age groups. *Accident Analysis & Prevention*, *117*, 239-249.
- Rehrl, K., Häusler, E., Leitinger, S., & Bell, D. (2014). Pedestrian navigation with augmented reality, voice and digital map: final results from an in situ field study assessing performance and user experience. *Journal of Location Based Services*, *8*(2), 75-96.
- Scott-Parker, B., & Oviedo-Trespalacios, O. (2017). Young driver risky behaviour and predictors of crash risk in Australia, New Zealand and Colombia: Same but different?. *Accident Analysis & Prevention*, *99*, 30-38.
- Shams, Z., Mehdizadeh, M., & Sanij, H. K. (2020). "I neither sleep well nor drive cautiously": How does sleep quality relate to crash involvement directly and indirectly?. *Journal of Transport & Health*, *18*, 100907.
- Shams, Z., Naderi, H., & Nassiri, H. (2021). Assessing the effect of inattention-related error and anger in driving on road accidents among Iranian heavy vehicle drivers. *IATSS research*, *45*(2), 210-217.
- Shen, B., Ge, Y., Qu, W., Sun, X., & Zhang, K. (2018). The different effects of personality on prosocial and aggressive driving behaviour in a Chinese sample. *Transportation research part F: traffic psychology and behaviour*, *56*, 268-279.
- Soliman, A., Alhajyaseen, W., Alfar, R., & Alkaabi, I. (2018). Changes in driving behavior across age cohorts in an Arab culture: the case of state of Qatar. *Procedia computer science*, *130*, 652-659.
- Sullman, M. J., Stephens, A. N., & Taylor, J. E. (2019). Dimensions of aberrant driving behaviour and their relation to crash involvement for drivers in New Zealand. *Transportation research part F: traffic psychology and behaviour*, *66*, 111-121.
- Sundström, A. (2008). Self-assessment of driving skill—A review from a measurement perspective. *Transportation Research Part F: Traffic Psychology and Behaviour*, *11*(1), 1-9.

Tao, D., Zhang, R., & Qu, X. (2017). The role of personality traits and driving experience in self-reported risky driving behaviors and accident risk among Chinese drivers. *Accident Analysis & Prevention*, 99, 228-235.

World Health Organization. (2021). *Road traffic injuries*. Retrieved 1 July 2021, <https://www.who.int/>

Zhou, D., Liu, H., Ma, H., Wang, X., Zhang, X., & Dong, Y. (2020). Driving behavior prediction considering cognitive prior and driving context. *IEEE Transactions on Intelligent Transportation Systems*, 22(5), 2669-2678.