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Motorcycle Blind Spot Detection: A Two-Way Awareness

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ABSTRACT – *This study aims to analyze the factors that significantly influence motorcycle riders' intention to adopt Blind Spot Detection (BSD) technology. By integrating the framework of the Theory of Planned Behaviour (TPB) and the Technology Acceptance Model (TAM), this research examines how latent variables such as Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude toward the Behaviour (ATP), Subjective Norm (SN), and Perceived Behavioural Control (PBC) collectively shape behavioural intention. The empirical data were collected from 450 respondents and analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The descriptive analysis results indicate that although the majority of respondents (80.9%) are familiar with the BSD symbol and 84% understand its function, a significant "awareness gap" exists, where only 60.4% of respondents know the appropriate response action when the BSD indicator lights up. Furthermore, the PLS-SEM analysis reveals that subjective norms are the strongest predictor in the formation of a positive attitude toward BSD. Significant indirect effects were also identified, confirming the crucial role of intention to use as a mediating variable. These findings provide a theoretical contribution by enriching the understanding of the motivations behind the adoption of safety technology and offer practical implications for educational strategies that focus not only on information but also on shaping behaviour and social norms.*

KEYWORDS: Blind Spot Detection (BSD), car, motorcycle, safety features**,** road safety

1. INTRODUCTION

Continuous innovation in the automotive industry aims to enhance driving safety. One of the main challenges, particularly for motorcycle riders, is the problem of blind spots – areas around the vehicle that are not visible through the rearview mirrors. The inability to detect other vehicles in a blind spot is a common cause of accidents, which is a critical issue in road safety (Aziz et al., 2020). To address this problem, Blind Spot Detection (BSD) technology was developed as an advanced solution that provides visual or auditory warnings to the driver when another vehicle is in the blind spot area (Kassim et al., 2019).

The relevance of this research is reinforced by empirical data from a survey involving 450 motorcycle rider respondents. The findings demonstrate that the blind spot issue is not merely a theoretical problem, but a highly relevant and often dangerous reality. A total of 282 respondents (62.7%) reported having experienced a near-accident, and 229 respondents (50.9%) have been in an accident. These statistics provide a strong justification for the urgency of this study, emphasizing the pressing need to understand the factors that drive the adoption of safety technologies like BSD. Without effective adoption, the potential safety benefits of this technology cannot be optimally realized.

Although BSD offers clear safety benefits, the adoption of this technology by motorcycle riders is not a straightforward process. The intention to adopt new technology is influenced by various factors, ranging from an individual's cognitive evaluation of its benefits and ease of use to the influence of the social environment. Therefore, the main research question posed is: what psychological and social factors significantly influence motorcycle riders' intention to use BSD technology? To answer this question, this study integrates two relevant theoretical models – the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB) – to build a more comprehensive framework for analyzing adoption intention.

The primary objectives of this research are:

- To test and validate an integrated TAM and TPB model in the context of adopting BSD technology on motorcycles; and
- To identify and measure the direct and indirect influence of various theoretical constructs (perceived usefulness, perceived ease of use, attitude, subjective norm, and perceived behavioural control) on motorcycle riders' intention to use BSD technology.

This study is expected to make significant contributions in two main areas. Theoretically, this research enriches the literature by testing and validating the integrated TAM-TPB model in the context of adopting driving safety technology. This integration provides a more holistic understanding by combining the internal cognitive factors from TAM with the social and behavioural control dimensions from TPB. Practically, the findings of this study can serve as valuable guidance for motorcycle manufacturers, marketers, and policymakers. By understanding the factors that drive adoption intention, they can design more effective promotional and educational campaigns to increase awareness and, ultimately, encourage the use of BSD technology, which directly contributes to improving road safety.

2. METHODOLOGY

2.1 Literature Review and Hypothesis Development

Blind Spot Detection (BSD) is a driver assistance system that functions as a warning mechanism to detect other vehicles in the rider's blind spot area. In the context of this research, BSD is defined as a warning system that detects vehicles in a blind spot, not as a substitute for driver vigilance. Its main objective is to reduce the risk of accidents caused by unsafe lane-changing maneuvers.

The Technology Acceptance Model (TAM), developed by Davis (1989), is a theoretical framework designed to predict the likelihood of an individual or organization adopting a new technology system (Dziak, 2024). TAM posits that a user's motivation to adopt technology is influenced by two main factors: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU is defined as the extent to which a user believes that the technology will assist them in accomplishing a desired task. Meanwhile, PEOU refers to the user's perception of how easy the technology is to operate. The underlying logic of this model is that if an application is perceived as easy to use, it is more likely to be considered useful, which in turn will stimulate technology acceptance.

The Theory of Planned Behaviour (TPB) is a psychological framework that explains human behaviour by analyzing individual intentions. Developed by Icek Ajzen (1991; 2020) as an extension of the Theory of Reasoned Action (TRA), TPB adds the construct of Perceived Behavioural Control (PBC) to accommodate factors beyond an individual's control that may influence behavior. TPB argues that a person's behavioural intention is formed by three core components: Attitude toward the Behaviour (ATP), Subjective Norm (SN), and Perceived Behavioural Control (PBC). ATP is an individual's positive or negative evaluation of performing the behaviour. SN is an individual's perception of social pressure to perform or not perform the behaviour. Lastly, PBC is an individual's belief about their capability and ease of performing the behaviour. These three components collectively form an intention which, in turn, is the direct antecedent of actual behaviour.

The integration of the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB) results in a more robust and comprehensive research model. TAM specifically focuses on technology-related beliefs, namely Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). These beliefs can then be viewed as external factors that influence the core components of TPB, namely Attitude toward the Behaviour (ATP) and Perceived Behavioural Control (PBC). Meanwhile, TPB introduces a social dimension through Subjective Norm (SN), a factor absent in the basic TAM model. By integrating these two models, this study is capable of capturing internal motivations (PU, PEOU), cognitive evaluations (ATP, PBC), and social influences (SN) that holistically affect the intention to use technology (Intention to Use or ITU). This integration allows for a deeper understanding of how perceptions of technology shape attitudes and perceived control, and how social influence modulates adoption intention, ultimately providing a more complete explanation of safety technology adoption behaviour.

Based on the theoretical review and model integration, a series of hypotheses were developed to test the causal relationships between the latent variables:

- H1: Perceived Ease of Use (PEOU) has a positive influence on Perceived Usefulness (PU).
- H2: Perceived Usefulness (PU) has a positive influence on Attitude toward the Behaviour (ATP).
- H3: Perceived Ease of Use (PEOU) has a positive influence on Attitude toward the Behaviour (ATP).
- H4: Attitude toward the Behaviour (ATP) has a positive influence on Intention to Use (ITU).
- H5: Subjective Norm (SN) has a positive influence on Intention to Use (ITU).
- H6: Perceived Behavioural Control (PBC) has a positive influence on Intention to Use (ITU).
- H7: Intention to Use (ITU) has a positive influence on Attitude toward the Behaviour (ATP).

2.2 TAM (Technology Acceptance Model) – TPB (Theory of Planned Behaviour)

The research adopts a quantitative approach with a correlational design. The objective is to test the causal relationships between the latent variables defined in the integrated TAM-TPB model. The target population for this study is motorcycle riders. The sample used in this research consists of 450 respondents. An important limitation in this study is that the survey document does not include descriptive data on the distribution of respondents by education and occupation. The absence of this information limits the ability to perform a more detailed demographic analysis and may affect the generalizability of the research findings.

Data were collected through a questionnaire instrument designed to measure each of the latent constructs: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude toward the Behavior (ATP), Subjective Norm (SN), Perceived Behavioural Control (PBC), and Intention to Use (ITU). Each construct was measured with several indicators to ensure validity and reliability.

Descriptive analysis was used to present the basic characteristics of the respondents based on the available survey data. Its purpose is to provide an initial overview of respondents' understanding and experience with BSD technology before proceeding to a more in-depth analysis.

The main data analysis in this study uses Partial Least Squares Structural Equation Modelling (PLS-SEM) (Hair et al., 2021; Ringle et al., 2022). PLS-SEM was selected because it is a suitable method for analyzing complex cause-and-effect relationships in path models involving latent variables. The advantage of PLS-SEM lies in its flexibility regarding data requirements and model specifications, making it a robust methodological choice for this predictive research model.

The PLS-SEM analysis was performed in two stages:

1. Measurement Model Evaluation (Outer Model): This stage focuses on testing the validity and reliability of the latent constructs.
2. Structural Model Evaluation (Inner Model): This stage focuses on testing the proposed hypotheses by analyzing path coefficients and mediation effects.

3. RESULTS AND DISCUSSION

The descriptive analysis provides an important initial overview of respondents' understanding and experience with BSD technology. Out of a total of 450 respondents, the majority (364 people, or 80.9%) were familiar with the BSD symbol, while 86 people (19.1%) were not familiar. Most respondents (378 people, or 84%) also understood the main function of BSD as a detector of vehicles in blind spots. Most respondents (350 people, or 77.8%) were aware that BSD is only a warning and not a substitute for driver vigilance. However, despite the relatively high level of awareness regarding the function and limitations of BSD, only 272 respondents (60.4%) knew that the most appropriate action when the BSD indicator lights up is to manually check the rearview mirror and blind spot.

This data identifies a clear discrepancy between knowledge (Perceived Usefulness) and correct action (Intention to Use). The fact that only 60.4% of respondents knew the correct action indicates that current educational efforts may be more successful in increasing feature recognition than in changing behavior. This suggests the existence of an "awareness gap" where knowledge does not always translate into correct behavior.

The following table presents a summary of the descriptive analysis based on the available data:

TABLE 1: Summary of respondent descriptive analysis

Description	Number of Respondents	Percentage
Total Respondents	450	100%
Familiar with the BSD symbol	364	80.9%
Understand BSD function	378	84.0%
Understand correct action when indicator lights up	272	60.4%
Aware that BSD is only a warning	350	77.8%
Have experienced a near-accident	282	62.7%
Have experienced an accident	229	50.9%

The measurement model evaluation indicates that all indicators used to measure the latent constructs have very high outer loadings, with values approaching 1.00. These values provide strong evidence that each indicator reliably measures its intended construct, affirming the convergent validity and reliability of the measurement model. The structural model analysis tests the relationships between the latent variables. The findings from the path coefficients, total indirect effects, and total effects are summarized in the following table:

TABLE 2: Summary of Direct, Indirect, and Total Effects Analysis (PLS-SEM)

Path Relationship	Direct Effects (Path Coefficients)	Indirect Effects (Total Indirect Effects)	Total Effects (Total Effects)
ITU 1 -> ATP 1	0.354	-	0.354
ITU 2 -> ATP 2	0.261	-	0.261
ITU 3 -> ATP 3	0.170	-	0.170
PBC 1 -> ATP 1	0.071	0.090	0.161
PBC 1 -> ATP 2	0.161	0.053	0.214
PBC 1 -> ATP 3	0.029	0.064	0.093
PBC 1 -> ITU 1	0.255	-	0.255
PBC 1 -> ITU 2	0.201	-	0.201
PBC 1 -> ITU 3	0.379	-	0.379
PBC 2 -> ATP 1	-0.067	0.071	0.004
PBC 2 -> ATP 2	-0.004	0.043	0.039
PBC 2 -> ATP 3	0.080	-0.004	0.077
PBC 2 -> ITU 1	0.200	-	0.200
PBC 2 -> ITU 2	0.166	-	0.166
PBC 2 -> ITU 3	-0.022	-	-0.022

Note: *The values presented have been rounded for ease of interpretation.*

TABLE 2: (Continued)

Path Relationship	Direct Effects (Path Coefficients)	Indirect Effects (Total Indirect Effects)	Total Effects (Total Effects)
PEOU 1 -> ATP 1	-0.048	0.026	-0.022
PEOU 1 -> ATP 2	0.046	0.042	0.088
PEOU 1 -> ATP 3	-0.088	0.005	-0.083
PEOU 1 -> ITU 1	0.074	-	0.074
PEOU 1 -> ITU 2	0.160	-	0.160
PEOU 1 -> ITU 3	0.030	-	0.030
PEOU 2 -> ATP 1	0.063	0.083	0.146
PEOU 2 -> ATP 2	0.096	0.003	0.099
PEOU 2 -> ATP 3	0.358	0.031	0.390
PEOU 2 -> ITU 1	0.235	-	0.235
PEOU 2 -> ITU 2	0.010	-	0.010
PEOU 2 -> ITU 3	0.185	-	0.185
PU 1 -> ATP 1	0.139	0.021	0.160
PU 1 -> ATP 2	0.020	0.056	0.076
PU 1 -> ATP 3	0.076	0.021	0.097
PU 1 -> ITU 1	0.058	-	0.058
PU 1 -> ITU 2	0.216	-	0.216
PU 1 -> ITU 3	0.125	-	0.125
PU 2 -> ATP 1	0.070	-0.014	0.056
PU 2 -> ATP 2	0.019	0.002	0.021
PU 2 -> ATP 3	0.016	0.013	0.029
PU 2 -> ITU 1	-0.040	-	-0.040
PU 2 -> ITU 2	0.008	-	0.008
PU 2 -> ITU 3	0.076	-	0.076
SN 1 -> ATP 1	0.415	-0.006	0.409
SN 1 -> ATP 2	0.126	0.067	0.193
SN 1 -> ATP 3	0.103	0.012	0.115
SN 1 -> ITU 1	-0.016	-	-0.016
SN 1 -> ITU 2	0.258	-	0.258
SN 1 -> ITU 3	0.071	-	0.071
SN 2 -> ATP 1	-0.077	0.057	-0.020
SN 2 -> ATP 2	0.213	-0.022	0.191
SN 2 -> ATP 3	0.224	0.004	0.228
SN 2 -> ITU 1	0.161	-	0.161
SN 2 -> ITU 2	-0.086	-	-0.086
SN 2 -> ITU 3	0.023	-	0.023

Note: *The values presented have been rounded for ease of interpretation.*

The analysis of path coefficients reveals several significant findings. The path coefficient with the highest value is the relationship between Subjective Norm (SN 1) and Attitude toward the Behaviour (ATP 1), with a value of 0.415. This finding indicates that the influence of the social environment or pressure from relevant social groups is the strongest driver in shaping an individual's positive attitude toward BSD technology. This suggests that motorcycle riders are more likely to have a favorable attitude toward BSD if they feel that their family, friends, or community expect them to use the technology.

Conversely, some relationships show a weak or even negative influence. For instance, the path coefficient from PBC 2 to ITU 3 is -0.0217, while the path from SN 1 to ITU 1 is -0.0163. These findings indicate that the influence is not always uniform across all dimensions of the model, and some aspects of perceived behavioural control or subjective norms may be irrelevant or even inhibit adoption intention. This complex relationship suggests that a more in-depth analysis is needed to identify and understand the specific factors behind these unexpected relationships.

Table 2 also includes data on Total indirect effects, which confirms the important role of intention to use (Intention to Use or ITU) as a mediating variable. For example, the relationship between PBC 1 and ATP 1 has a direct effect of 0.071 and an indirect effect of 0.0902. This indirect effect occurs through the mediating variable ITU, meaning that the influence of perceived behavioural control on the attitude toward BSD is not only direct but also significantly mediated by the individual's intention to actually use the technology. This finding provides substantial confirmation of the proposed theoretical model.

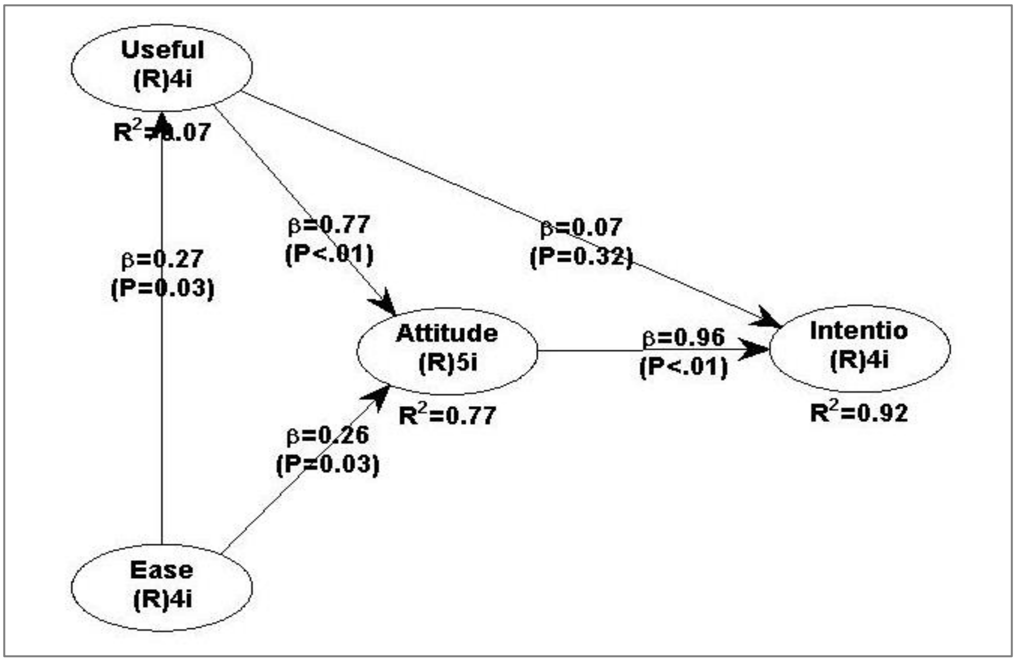

FIGURE 1: TAM result

The role of culture in shaping an individual's subjective norms regarding the selection of vehicles equipped with Blind Spot Detection (BSD) technology is highly significant, particularly in how culture influences social pressures and collective values related to safety, status, and technology adoption. Subjective norms refer to an individual's perception of social pressures to engage in or refrain from a specific behaviour (in this case, choosing a vehicle with BSD) from individuals or groups deemed important (referents), such as family, friends, or society at large. Culture impacts subjective norms related to safety technologies like BSD in several key ways:

(a) Collective Safety Values

Collectivist vs Individualistic Cultures: In societies with a strong collectivist culture (where group interests are prioritized), the safety and well-being of group members (e.g., family) are highly valued. The social pressure (subjective norms) to purchase vehicles that ensure safety, including BSD features, tends to be stronger, as this behaviour is viewed as responsible and supported by group norms.

Individualistic Culture: Conversely, in individualistic cultures, purchasing decisions may be more influenced by personal benefits, such as comfort or performance, even though safety remains important. Subjective norms related to safety features may not be as pronounced in collectivist cultures.

(b) Technology Adoption and Trust

Acceptance of Innovation: Culture can determine how quickly and easily society embraces new driving technologies. If there is a cultural tendency to be skeptical of technological interventions or if individuals rely more on their driving skills, subjective norms for adopting BSD features may be low, even if close acquaintances advocate for them.

Status Expectations: In some cultures, owning a vehicle with advanced technology (such as BSD) is not only viewed as a safety factor but also as a status symbol, representing prosperity or modernity. Social pressure (subjective norms) from peers or social environments to possess these features may increase due to their association with the desired social image.

(c) Expected Driving Behaviour

Traffic Culture: Cultural norms related to ethics and behaviour on the road (e.g., adherence to rules, levels of aggressive driving) can influence how society perceives the need for features like BSD. If the traffic culture tends to be disorderly or has a high rate of violations, social pressure to have BSD as an additional safeguard (beyond mere safety) may increase. If safe driving is already a strong norm embedded in the culture (a culture of safe driving), BSD may be viewed as an essential tool that supports this normative behaviour, thereby reinforcing subjective norms for its adoption. If the culture highly values safety and technological advancement (in line with ongoing campaigns), then subjective norms (pressure from close contacts) to choose vehicles with BSD will become increasingly robust, encouraging individuals to engage in this purchasing behaviour.

The results of this study demonstrate that the integrated TAM-TPB model successfully provides a comprehensive explanation of the intention to adopt BSD technology. The high number of accidents and near-accidents among respondents indicates that the perceived usefulness (Perceived Usefulness) of BSD is highly relevant. However, the adoption of this technology is not driven solely by its functional benefits. The strongest influence on attitude formation comes from subjective norms (Subjective Norm), which shows that motorcycle riders are social actors who are influenced by their environment.

Furthermore, the descriptive analysis identifies a crucial gap between knowledge and behaviour. Although many respondents are familiar with and understand BSD, only about 60% know the correct action when the system is active. This highlights that existing educational strategies may be overly focused on features and benefits, and insufficiently on shaping correct behaviour. Therefore, a more holistic approach is needed to promote integrated and comprehensive awareness

4. CONCLUSION

This study concludes that the integrated TAM-TPB model is a valid and effective framework for analyzing the intention to adopt BSD technology among motorcycle riders. Key findings affirm that Subjective Norms are the primary driver of positive attitude formation toward BSD. Although awareness of the technology's function is quite high, a significant gap exists in understanding the correct actions to take when BSD is active, which impacts adoption intention and safety behaviour.

These findings suggest that promotional and educational campaigns need to go beyond simply socializing the function of BSD. Manufacturers and marketers should collaborate with motorcycle communities and leverage respected influencers to build positive social norms and encourage the use of BSD. Education should focus on correct driving practice simulations, emphasizing the importance of manually checking mirrors and blind spots even when the BSD indicator is not lit. Emphasizing the technology's limitations is as crucial as highlighting its benefits. The placement of the BSD symbol in easily visible locations, such as on the infotainment screen and rearview mirrors, should also be maintained to ensure quick recognition.

This research contributes to the literature by demonstrating how TAM and TPB can be combined to provide a more holistic insight into the context of adopting safety-related technology. The dominant role of subjective norms in shaping attitudes underscores the importance of considering social factors in technology acceptance models.

While the integrated TAM–TPB model effectively explains riders' behavioural intentions, several limitations should be noted. First, the study did not collect detailed demographic information such as education level or occupation, limiting the ability to conduct subgroup analyses. Including these variables in future studies would enable a more nuanced understanding of how demographic characteristics moderate the adoption process. Furthermore, future research could also measure actual adoption behaviour, not just intention, to test the extent to which the intentions measured in this study truly translate into real-world action. This would provide a more complete understanding of the entire technology acceptance process. Second, the influence of cultural context should be acknowledged. In societies with strong collectivist orientations, social approval and community norms play a significant role in shaping behavioural intentions. The strong effect of subjective norms found in this study likely reflects this cultural tendency. Future research comparing results across different cultural contexts would help clarify the extent to which these findings are culturally specific or generalizable.

Finally, the present study focuses on intention rather than actual adoption behaviour. Longitudinal or follow-up studies that track real-world Blind Spot Detection usage would provide valuable insights into how intentions translate into practice and whether behavioural change occurs over time.

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