A Predictive Model of Motorcycle Accident Involvement Using Structural Equation Modeling Considering Driver Personality and Riding Behavior in Metro Manila

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ABSTRACT

Road traffic accidents involving motorcycles have been seen to have an upward trend in the Philippines. Previous study by Flores, Gotohio and Paras (2008) was the first and only study that considered linking motorcycle accidents with environmental and personal factors: age, lighting conditions, traffic movement, weather conditions, road character, junction type, time, day, surface conditions and driver behavior. The study fails to expound on the concept of driving behavior as well as failed to include the personality of the driver. The independent variables of the study are driver personality and riding behavior while the dependent variable is accident involvement. The chosen method to analyze the data is Structural Equation Modeling (SEM). The scope of the study would only be in Metro Manila the capital of the Philippines. The purpose of the study is to determine the relationships of driver personality and riding behavior factors as well as to predict accident involvement using the same factors. The findings of the study suggest that normlessness has an inverse relationship with accident involvement, while self-assertiveness, speeding, rule-violations and anger all exhibit a direct relationship.

Keywords: predictive model; Structural Equation Modeling (SEM); motorcycle accidents

1. INTRODUCTION

Driver behavior, mainly aggressive driving increases the likelihood of a motorcyclist getting into an accident. According to Angelito Vergel de Dios, executive director of the MMDA Traffic Operations Center (2006, as cited in Flores, et al., 2008), the continuous increase in motorcycle accidents roots from the motorcyclists driving on the curb, the sidewalk, and just continuously swerve and zig-zag their way through traffic. Driving style or driving behavior of either handling a motorcycle or a standard four- wheeled vehicle could be a factor that yields to a road traffic accident. A study conducted by Sabbour et al. (2010) focused on analyzing the driving behaviors of students in relation to driving accidents. Driving behavior or style included: driving with excessive speed, deviance, calmness, concentration, violations, usage of safety belt, participation in risky conditions etc. The results of their study indicated that driving style and driving behavior were significantly higher among males and the factors were indeed significant in the involvement of such road traffic accidents.

In order to create a more accurate and detailed predictive model, the factors considered significant would be included, wherein driver behavior would be further delved upon, as well as the personality of the driver, wherein both variables will be tested as significant predictors of motorcycle accidents. Furthermore, a research study conducted by Valentine, et al. (1977) for the office of traffic safety suggests that "man drives as he lives" and that those having trouble or difficulty with the personal as well as social demands of living would tend to make repeated driving errors. The results of their study indicate that the long-term repeaters of accident errors are characterized by these personalities: aggressiveness, impulsiveness, depression, anxiety and extroversion and theories suggest that driver personality deterioration in individuals could lead to accident

behavior. Currently, there are no implemented laws that specifically cater to the needs of motorcyclists in Metro Manila, other than the helmet law which is implemented across the country. According to the short interviews conducted with various motorcycle users, one of the prominent reasons why they continue to execute risky driving behavior, such as speeding, swerving, and the like, is because they want to get to their destination at the least possible time, even if it means that these actions would produce inconveniences to other road users. Plus, these motorcycle users also know that the degree of traffic enforcement is pretty low, which gives them confidence to continue these bad driving practices, which could potentially lead to a motorcycle accident. This in turn continues the cycle of motorcycle accidents, because the drivers do not receive any fines or proper education about safe driving practices. Columbia is known to have some of the toughest penalties against drivers who drive under the influence. A minimum of 1 year and a maximum of 10 years of license suspension is given to those who are convicted of driving under the influence. There are also hours of community service (20-50 hours) and safe driving practices seminars that are required, while imprisonment of 2.5 to 18 years is also given to those who caused grave injuries and deaths. In Taiwan, a minimum of license suspension of 1 year accompanied with a possible prison sentence of up to 2 years is given to those convicted of driving under the influence. If the driver was able to inflict grave injuries and death, the license is suspended for a lifetime, and may even receive the death penalty on extreme cases. However, the penalties incurred by drivers who commit traffic violations in the Philippines only range from paying penalties up to 6 months suspension of driver's license, and even confiscation of the plate number of the vehicle. Moreover, the policies only tackle short-term improvements and do not cater to changing the unsafe driving behavior of the motorcyclists. The policies are implemented only to scare and to inform drivers that they are doing activities that are deemed illegal, instead of changing the ways of the drivers that will implement positive and long-term change. An example of action that can be done is through integrated policy making sessions that will take into account the opinions of all the stakeholders, such as the drivers, the pedestrians, the government agencies, and the lawmakers. The inefficiency of law enforcement, with a combination of inefficient policies, greatly contribute to the ever increasing number of motorcycle accidents in Quezon City and Metro Manila.

Previous studies have not taken into account the effects of driver personality and riding behavior in examining the occurrence of motorcycle accidents in Metro Manila. The study aims to: (1) determine the effects of driver personality and riding behavior on motorcycle accident involvement, (2) identify which of the aforementioned factors are significant contributors to motorcycle accident involvement, (3) identify the relationship between driver personality and riding behavior, (4) provide safety policies and safety programs to be implemented by government agencies.

1.1 Hypothesis of the Study

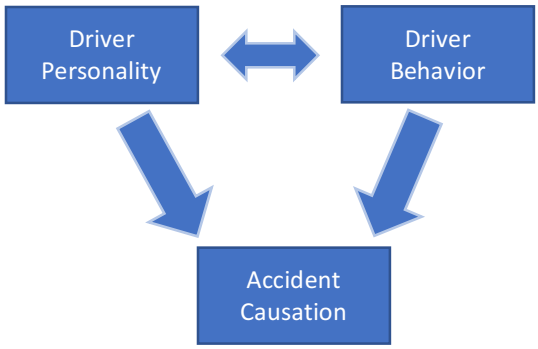

Figure 1. Hypothesis of the Study

H1. There is a relationship between driver personality and riding behavior

The study by Falco et al. (2013) established the role of driver personality in influencing rider behavior directly. Moreover, the results of their study have shown the predictive capabilities of personality traits, due to its direct impact on riding behavior. Riders have the capacity to lean on their strong emotions and sensation-seeking desires in order to overcome their own riding limits. Various studies have related driver personality to riding behavior. The study by Shahar (2009) stated that highly anxious individuals tend to have higher chances of being involved in riskier driving behaviors. Studies

riding behavior. Another study conducted by Ulleberg & Rundmo (2003) found that personality actually has an influence on risky driving in an indirect measure through the attitudinal measurements of riding behavior.

H2. There is a relationship between driver personality and accident involvement

Personality traits such as sensation-seeking, aggression and social deviance are found to be frequently related to involvement in traffic accidents (Ulleberg and Rundmo, 2003). Furthermore, in the study by Goyal et al. (2015), the researchers were able to determine that histrionic (overly dramatic or melodramatic), impulsive, and dissocial traits were shown to be pro-accident in nature while schizoid (emotionally aloof), anankastic (OCD), anxious, and dependent were found to be protective in nature, thus preventing motorcycle accidents. One of the five personality traits, anger, was found to be a significant predictor of accident involvement (Iversen & Rundmo, 2002).

H3. There is a relationship between riding behavior and accident involvement

The study by Owsley, McGwin & McNeal (2003) was able to establish that riders who are classified as highly impulsive were more likely, than those classified in the low impulsivity group, to have higher driving errors and higher violations which could further lead to accident involvement. However, in the study by Constantinou et al. (2011) found that the results of their study only had small positive correlations between motor impulsivity, thrill-seeking, and adventure-seeking with self-reported motor accidents. According to the study by Sarma et al (2013), individuals who speed and commit rule-violations were highly correlated with higher levels of angry behavior, which could be related to accident involvement.

H4. The components of driver personality have multiple interaction effects on riding behavior

H4A. The components of driver personality have multiple interaction effects on self- assertiveness

Various studies have taken into account the multiple interaction effects of driver personality components on self-assertiveness. The study by Wong et al. (2010) established that sensation-seeking riders are exceptionally confident about their riding skills and are more inclined to attaining higher self-worth by conducting unsafe riding activities. In the study by Chen (2009), driver personality can be a significant predictor of risky riding behavior, which includes self-assertiveness.

H4B. The components of driver personality have multiple interaction effects on speeding

The study by Berdoulat et al. (2013) examined the effects of driving anger with aggressive and transgressive driving. The results of the study showed that drivers who are angry while driving have a tendency to over speed when driving. Meanwhile, anxious and altruistic drivers tend to be more cautious of their driving behaviors, which lessens the probability of over speeding (Chen, 2009). According to the study by Zuckerman (1994), individuals who are sensation-seekers have higher chances of over speeding and bending the rules, as their personality trait prevents them from having any disinhibition with regards to performing risky driving behavior.

H4C. The components of driver personality have multiple interaction effects on rule violations

Rule violations is when a motorcyclist breaks the rules while driving. It is believed that driver personality has a relationship with the probability of a driver committing violations of the rules. Various studies have put emphasis on the role of sensation seeking in driving behavior and results. Sensation seeking is a "trait expressed by the seeking of varied and intense sensations and experiences and the inclination to take physical, social, legal, and financial risks for the sake of attaining such experiences" (Zuckerman, 1994). Those who are determined to score high in sensation seeking tests are assumed to engage in reckless driving behavior in the near future in order to attain such sensation. Anger is also a predictor of rule-violations, as explained in the studies by Berdoulat et al. (2013) and Deffenbacher et al. (2003). Both studies have shown that drivers were more likely to violate rules and over speed when they experience situations that make them angry. Drivers who are angry reported more frequent anger which resulted to more aggression and risky driving behavior during daily driving experiences and tend to have more frequent close calls and road violations. In the study by Ulleberg & Rundmo (2003), the results of the study have shown that altruistic and anxious individuals perceive risks related to traffic accidents as generally high. Individuals possessing both personality traits also had a positive attitude towards traffic safety which resulted to less risk-taking during driving activities. In the same study, the respondents who scored high on normlessness perceived traffic accident risks as lower, displayed an opposing view on traffic safety, and reported more risk-taking activities while driving.

2. METHODOLOGY

The basic flow of the research methodology is as follows: (1) Review of Related Literature to determine the Research Gap, (2) Data Gathering, (3) Analysis and interpretation of data and (4) Policy-making. The determination of the research problem involves steps in determining what area to tackle and narrowing down of topics to a manageable level. Review of Related Literature consists of studying previous researches conducted on the chosen

and distribution of a survey. The analysis of data would be done using Structural Equation Modeling (SEM). Lastly, policies/programs would be made, with respect to the insights found in the previous stages. The breakdown of the whole research methodology is shown below:

2.2 Data Gathering

The survey questionnaire is the essential source with regards to the data the group would need to gather in order to construct or determine the predictive model of motorcycle accidents utilizing the Structural Equation Modelling statistical tool. To be able to generate good results from the statistical software, a total of 200 samples would be collected, wherein 150 would be used for the final model and 50 for the validated model.

2.2.1 Creation of Survey

The surveys that would be utilized in the study are the surveys pertaining to the five personality traits, which were gathered from the International Personality Item Pool and the study of Kohl & Schooler (1983). For the riding behavior questionnaire, the survey by Ulleberg & Rundmo (2003) will be utilized. Lastly, the accident occurrence questions, adapted from the survey of the Transport Research Planning Group Survey Questionnaire, would be used to determine the accidents of the respondents. The most common questions that were removed had the topic of training courses and endorsements, which are not present and/or mandatory in the Philippines. Questions regarding factors not included in the study were also removed. In addition, some questions wherein it involves the admission of mistakes by the participant were also removed as it was found that people are reluctant to admit their own mistakes. The inclusion of these kinds of questions might distort the model and/or prove to be insignificant due to the lack of honesty by the participants.

2.2.2 Distribution of Survey

The main source of data for this study will be obtained through surveys. However, there is a prerequisite to becoming a participant, which are: (1) possesses a license and (2) has motorcycle-riding experience, (3) capable of understanding both English and Filipino, and (4) a resident of Metro Manila. This will be the screening process before picking a participant as well as handing out the survey. The reason for the disregard of other factors such as gender, age and other demographic factors is that these are not included in the study to be done. In order to reduce the time to screen participants or eliminate it completely, the venue chosen would serve as the justification for the participants. The distribution of surveys will be conducted during the annual reunion of the Quezon City Motorcycle Riders Federation (QCMRF). The members of the said organization are known to be motorcycle riders and enthusiasts who reside in Quezon City. To gather more data, the surveys will also be distributed to respective Land Transportation Offices (LTO) in Quezon City and Muntinlupa City. To reduce the possibility of any errors or misunderstandings everything was kept uniform through the preparation of a script to be used. After each respondent has answered the survey, the respondent was debriefed and was given a token of appreciation, the gathered data was organized and analyzed through structural equation modeling in order to address the different hypotheses.

2.5 Analysis of Data using Structural Equation Modeling

Structural Equation Modeling (SEM) was the statistical approach used to determine the predictive model for motorcycle accidents. It makes use of confirmatory factor analysis to determine whether the factors considered in the study are significant or not. The AMOS Software was used in order to execute structural equation modeling, along with the help of SPSS. The reason for choosing SEM as the statistical approach to solving the problem is that it makes use of both observed variables and latent variables (unobservable). The latent variables included in the study are: riding behavior, driver personality, and accident involvement. These factors cannot be fully measured unlike riding experience, presence of protective equipment and past violations. Therefore, making SEM the perfect statistical tool for determining the significant factors, identifying causal relationships and creating a predictive model. The study will utilize Anderson and Gerbing's (1988) two-step approach to structural equation modeling. The first step is to determine model validity and reliability while the second step is performing a confirmatory factor analysis (CFA) in order to assess model fit and statistical acceptance. SEM will also provide recommendations or suggestions on how the model can be further improved. However, these alterations have no assurance of making the model better or increasing the accuracy, so the different suggestions, such as by determining model validity and reliability, will be tested to see if it does make it better.

2.6 Policy-Making

The refinement of current policies is also a possibility as there might be policies already enacted but not that widespread or effective. These new and/or policies will be the main output of the research as it encompasses all the learnings from this study.

3. MODEL DEVELOPMENT

3.1 Data Screening

Before the predictive model is developed, the data that were collected would have to be screened prior to processing and analysis of data. The bad data and influential data points have to be identified in order to create a model that would be efficient and successful. For the survey questionnaires, answers that were obviously rushed (e.g. all answers have a single rating of 1) would be discarded as it could negatively affect the outcome of the study.

3. 2 Analysis of results

Prior to the conducting of statistical tests of the gathered data, it is first necessary to test the data for statistical acceptability. This can be done through obtaining the Cronbach alpha coefficient, which is used to evaluate the internal consistency of the data, basically it is said to measure scale reliability.

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Where: N = number of items
C-bar = average inter-item covariance
V-bar = average variance

The minimum acceptable reliability coefficient is 0.70, as this has been the common practice when used in researches. The recommended approach to solving SEM problems is the two-step approach to SEM by Anderson and Gerbing (1988) wherein the first step consists of checking the adequateness of the measurement model through confirmatory factor analysis (CFA). The second step then consists of pseudo chi-square tests between different models to come up with the final model. In addition to these pseudo chi-square tests, several fit indexes will be realized: goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI) and root mean square error of approximation (RMSEA). The minimum acceptable value of GFI, AGFI and CFI is 0.9, while RMSEA has a maximum acceptable value of 0.05.

3.3 Questionnaire Analysis

The reason for using these surveys is that the aforementioned surveys have already been used and established in the past, which means that there would not be any validity problems pertaining to the set of questions that pertain to each variable. The statements for driver personality are composed of both positively worded and negatively worded statements, with the former being the majority of the statements. For each factor of driver personality, there is at least one negatively worded statement. The following are the negatively worded statements for each factor of driver personality: keep my cool (Ang1) do not worry about things that already happened (Ang2), relaxed most of the time (Anx1), do not worry about things that already happened (Anx2), would never go hang gliding or bungee jumping (Sen5), indifferent to the feelings of others (Alt5), do not make time for others (Alt6), and dislike loud music (Alt7). These statements are considered to be negatively worded, as these statements convey the opposite meaning of their respective factor for driver personality. Thus, by having these negatively worded statements, the study would be able to reduce the acquiescent bias and extreme response bias. Acquiescent bias refers to the act of respondents of generally answering all statements with one response only (either agreeing or disagreeing). In a 5-point Likert Scale, the typical response would be answering all 4's and 5's. Extreme response bias is when respondents answer all high or all low ratings (in a 5-point Likert scale, they would either answer all 5's or all 1's) to the statements.

Table 1. Coding of Variables

Variable	Variable Abbreviation	Code Values
Anxiety	Anx	Anx1, Anx2, Anx3, Anx4, Anx5
Anger	Ang	Ang1, Ang2, Ang3, Ang4, Ang5
Sensation Seeking	Sen	Sen1, Sen2, Sen3, Sen4, Sen5
Altruism	Alt	Alt1, Alt2, Alt3, Alt4, Alt5, Alt6, Alt7
Normlessness	Norm	Norm1, Norm2, Norm3
Self-Assertiveness	Self	Self1, Self2, Self3, Self4, Self5
Speeding	Spe	Spe1, Spe2, Spe3, Spe4
Rule-violations	Rul	Rul1, Rul2, Rul3
Accident involvement	Acc	Acc1, Acc2

The table above illustrates the coding of variables that will be utilized in the feeding of the data into the AMOS Software and SPSS Software.

4. FINAL VALIDATION OF THE MODEL

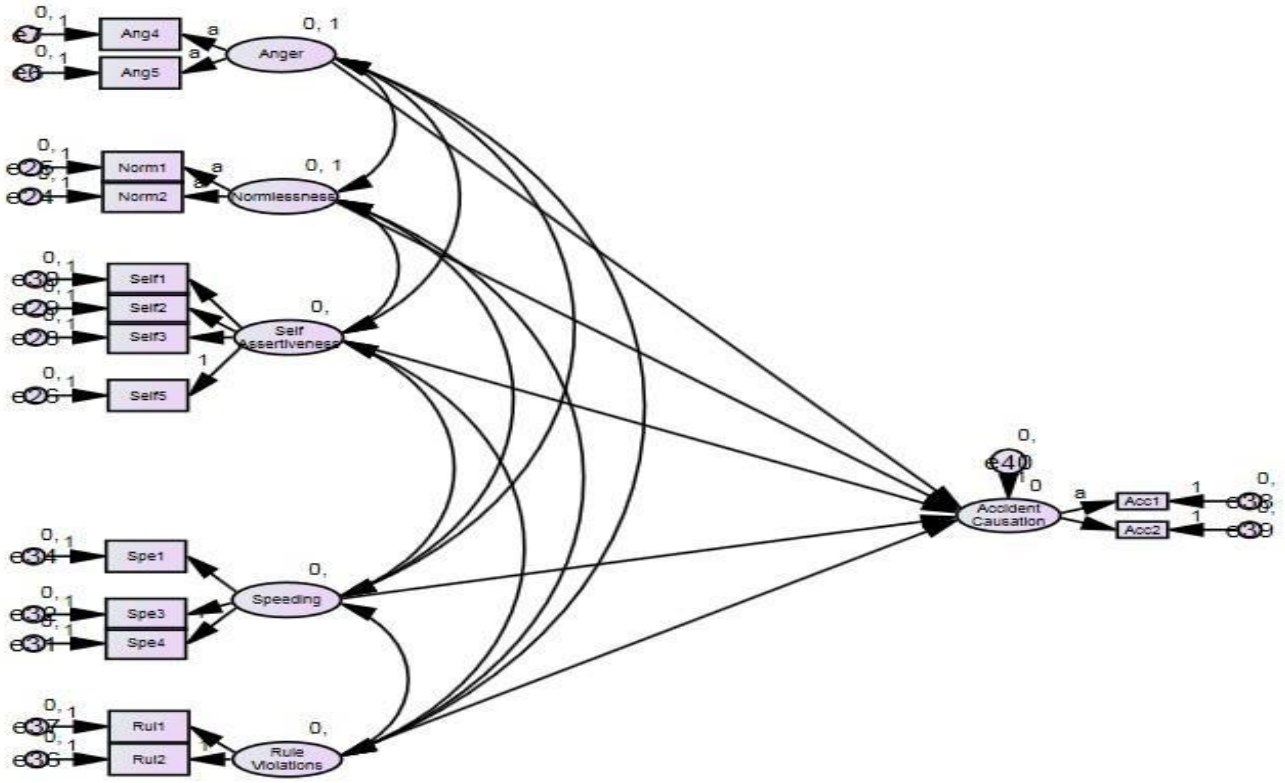

Figure 1. Finalized Model

The figure above illustrates the finalized model of the study that was determined via the iteration process. As explained previously, the remaining factors for driver personality are normlessness and anger while the factors for riding behavior remain intact.

4.1 Model Measurement

Table 2. Cronbach's Alpha for the Final Model

Latent Construct	Cronbach's Alpha
Driver Personality	
Anger	0.890
Normlessness	0.824
Riding Behavior	
Self-Assertiveness	0.910
Speeding	0.763
Rule Violations	0.587
Accident Involvement	
Accident Involvement	0.778

The table above lists the remaining variables of the study and their corresponding Cronbach's alpha values. As observed, all of the variables were able to achieve the set threshold for reliability, which signifies that the indicators are reliable.

5. RESULTS

Table 3. Comparison of correlations between final and validated model

Correlation	Final Model	Validated Model
Anger <-> Normlessness	-0.009	-0.003
Anger <-> Self-Assertiveness	0.159	0.210
Anger <-> Speeding	0.043	0.059
Anger <-> Rule-Violations	0.048	0.177
Normlessness <-> Self-Assertiveness	-0.167	-0.194
Normlessness <-> Speeding	-0.061	-0.096
Normlessness <-> Rule-violations	0.170	0.416
Self-Assertiveness <-> Speeding	0.422	0.819
Self-Assertiveness <-> Rule-violations	0.188	0.167
Speeding <-> Rule-violations	0.308	0.595

As can be seen in the comparison table above, despite the degree of variation between the final model and the validated model, the general behavior (sign) is the same for all correlations, meaning all interactions behave the same way whether the sample size used was the 150 samples or the 50 samples. This can only mean that the model does indeed cater to more than just the sample size garnered.

Table 4. Regression Weight to Accident Involvement

Predictor	Final Model (150 samples)	Validated Model (50 samples)
Self-Assertiveness	0.131	0.290
Speeding	0.549	0.376
Rule-violations	0.041	0.021
Anger	0.135	0.204

As can be seen above, the comparison between the regression weights of the final and validated model yielded of similar signs. In order to better determine the correct behavior of the variable, regression was conducted in excel to serve as a decision measurement, meaning the behavior garnered here would be the appropriate sign to use in the study. Upon conducting of Regression, the value retrieved from the Adjusted R Square for the 200 samples (both from final model and validated model) was -0.00644, meaning Normlessness has a negative relationship to accident involvement.

First, enough data was needed in order to be able to run or formulate the model and the data garnered was based through the formulation of a survey regarding road traffic accidents. A total of 200 samples were utilized, 150 samples for the model formulation and another 50 samples for the model validation. These data samples were evaluated and analyzed using the following software: AMOS and IBM SPSS. In order for the model to be fit, reliable, and valid, an iteration process was conducted. Through the iteration process, anxiety, sensation-seeking, and altruism were removed from the driver personality while no variables were removed for the factors of riding behavior. The results of the study have shown that variables of both driver personality and riding behavior have an innate relationship with each other that could potentially affect accident involvement. For the variables of driver personality, it was determined that normlessness has a negative relationship with accident involvement, while anger has a positive relationship with accident involvement. For the variables of riding behavior, it was determined that all 3 variables (self-assertiveness, speeding, and rule-violations) have a positive relationship with accident involvement. For the relationships of the factors of driver personality of riding behavior, it was determined that normlessness has a negative relationship with self-assertiveness and speeding, while having a positive relationship with rule-violations. On the other hand, anger has a positive relationship with self-assertiveness, speeding, and rule-violations. A validation of the final model was also done by utilizing 50 data samples. The model was deemed to be valid since classification accuracy of the model for validation was further analyzed and it was found to be acceptable. Lastly, six policies tackling the various variables were presented wherein four out of six policies were recommended to be implemented in the Philippines due to their costs, effectiveness, and likelihood of success. With the results of the present study, it can be concluded that the motorcycle accident involvement is influenced by the driver personality as well as the driver's riding behavior. Furthermore, the results of the study were able to determine that factors of driver personality correlated with the factors of riding behavior.

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